Duncan Graham

Transillumination of the face of a child with pus in the left antrum of Highmore arising from a defective tooth. Notice the light transmitted on the normal right side, especially by the eye.

[See page 27.]

INTERNATIONAL CLINICS

A QUARTERLY

OF

ILLUSTRATED CLINICAL LECTURES AND
ESPECIALLY PREPARED ORIGINAL ARTICLES

ON

TREATMENT, MEDICINE, SURGERY, NEUROLOGY, PÆDIATRICS, OBSTETRICS, GYNÆCOLOGY, ORTHOPÆDICS, PATHOLOGY, DERMATOLOGY, OPHTHALMOLOGY, OTOLOGY, RHINOLOGY, LARYNGOLOGY, HYGIENE, AND OTHER TOPICS OF INTEREST TO STUDENTS AND PRACTITIONERS

BY LEADING MEMBERS OF THE MEDICAL PROFESSION THROUGHOUT THE WORLD

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Special Articles

THE DIAGNOSIS AND TREATMENT OF ORAL SEPSIS: WITH REMARKS UPON ITS ETIOLOGY AND PREVENTION

By STERLING V. MEAD, D.D.S.

Professor of Röntgenology in former Dental Department of George Washington University; Chief, Department of Oral Surgery, Eastern Dispensary and Casualty Hospital, Washington, D.C.

Local manifestations of oral sepsis—known since early Hindu and Egyptian days—are to be found in three out of every five adults seeking medical or dental aid when their mouths and adjacent structures are properly examined, while two out of every three of those so affected will have sufficient evidence of harmful systemic infection to demand careful local and general treatment by those competent to give it. It is not so long since the ill-health caused by dental involvement was attributed to caries; then pyorrhœa (Riggs's disease) was blamed for most varieties of oral sepsis. But the whole subject was not placed on a truly scientific basis until the routine examination of the teeth by efficient X-ray operators showed that apical alveolar areas of infection, often well hidden in bone structure and not giving rise to any subjective or objective symptoms whatsoever, would sooner or later cause the appearance of pathological conditions in even the remotest portions of the body.

From my personal observations covering some thirty thousand carefully studied cases it would appear that there is need for a closer coöperation of the dental and medical professions in handling properly the problem of the effects of oral sepsis upon the general health of the patient.

On the one hand the medical profession should not overlook the value and the advantages of nature's own teeth, and should remember that no artificial restoration can really equal the tooth which has been extracted. The loss of a tooth involves the following considerations:

(1.) Masticatory efficiency impaired.

(2.) Elongation of opposing teeth.

(3.) Tipping of teeth, either side of the vacant space and bodily drifting.

(4.) Resorption of surrounding tissues.

(5.) Prosthetic restoration inferior to nature, from standpoint of utility and esthetics.

The medical profession, therefore, should not attempt to sacrifice teeth without due regard to their usefulness and positive assurance that they are causing general disturbance. This decision should be left to members of the dental profession.

On the other hand, the dental profession should more fully appreciate the position of the physician's interest in the welfare of the patient and understand more fully the evil effects of focal infection in the light of systemic disturbances. The dental profession is not in a position to attempt to diagnose general ailments and to endeavor to trace these conditions to the teeth, but should be able to determine accurately, and make an intelligent report, as to all pathological and contributing causes within the mouth when there is systemic trouble, and the probability of their being the source of a general infection or general derangement of any kind, and, more important still, positively to eliminate all dental sources of systemic disease.

It has been my observation that many physicians who fully believe in the teeth as a source of general disturbance are often handicapped in their efforts to eliminate oral sepsis by the hostile attitude of members of the dental profession who have contrary opinions. When the general health of the patient is at stake, and it is the opinion of the attending physician that the condition of the mouth is the cause, or an aggravating cause, of a systemic condition, or has even a suspicion to this effect, it should be the duty of any member of the dental profession to whom the patient is entrusted to be absolutely sure of his ground before expressing a contrary opinion, and to do this only after a most careful and painstaking examination, and in doubtful cases when practicable by a conference with some other member of the dental profession.

I believe that there is entirely too much haphazard examination of the mouth by the dental profession and an inclination to look too lightly upon these areas of oral sepsis. Many dentists consider the mouth solely from a mechanical standpoint. When we recall the many fads in medicine and dentistry and the many radical theories

Fig. 1.

Antero-posterior head view, showing normal frontal, maxillary, and ethmoid sinuses.

long ago forgotten, it is not hard to see why many in both professions are skeptical regarding the effects of oral sepsis upon the general system. However, those who see more and more of this class of work and note the mathematical precision with which the patients improve in their general health nine times out of ten when the oral foci are removed, feel most strongly that we are dealing with facts, and not with theories. Like medicine, dentistry is resolving itself into an era of prevention rather than with a period of restoration.

It is not uncommon to see a diagnosis made from a radiographic report, considering only the teeth and bone structure, and no attention given to unsanitary bridges, crowns, or other dental work, and in many cases the plate which the patient removes before the examination may be a most positive source of oral sepsis.

The gold crown, post crown, and fixed bridge are sources of great evil, and the vast majority of them as now made are failures, because of the irritation resulting from their careless use as well as pulpitis which may be produced through improper preparation of the tooth. With our present knowledge of and facilities for making inlay restorations and clasps and removable dentures and bridges, jacket crowns, etc., there would seem to be but little need for any undesirable work. It would seem better to be without teeth than to have undesirable dental restorations performed which will sooner or later prove a source of oral sepsis and subsequent systemic involvement. The first consideration should be the patient's health, and the second, the restoration. Many people have lived long lives with full dentures which were inferior to those which can be supplied to-day.

When the cause of a source of focal infection is eliminated in the mouth as elsewhere, it does not always mean that there will be an immediate improvement of general conditions, as it is necessary to give careful attention to the secondary effects of the primary focus. Since the progress of focal infection is usually so insidious, extensive pathological lesions have often been produced elsewhere before the true nature of the condition has been discovered. This is especially true in arthritis, where, more than in any other disturbance which I have observed, the inflammatory action continues long after the primary focus is removed. The simple stamping out of these oral areas of infection is not always, therefore, a sufficient means of effecting a cure without additional treatment by a skilled physician.

Pulpless teeth may be often left in the mouth to advantage.

A tooth from which the nerve is removed is not a dead tooth, nor a devitalized tooth. The tooth receives nourishment from two sources, the periodontal membrane and through the apex. When the pulp is removed, there is still a source of nourishment through the periodontal membrane. The tooth is not, then, a foreign body. When a tooth is extracted and replanted, both sources of nourishment have been destroyed, and there will be absorption of the root, as the tooth is then a foreign body.

The pulp of a tooth is the formative organ of the dentin and is transitory. If one lives to very old age it disappears; the tooth still lives since the cementum of the root receives its nutrition wholly from the periodontal membrane. The death of the pulp affords opportunity for apical infection, but if upon removal of nerve the root-canal is made aseptic and is hermetically sealed, the root does not usually become infected and alveolar abscess does not follow. This refutes the statement that "all pulpless teeth are a menace to health." If the periodontal membrane of a tooth is completely destroyed, the tooth becomes necrosed, and then and only then does it become a non-vital or dead tooth.

The normal pulp should rarely be devitalized, and only when necessary for relief of pain or the preservation of the tooth, or where necessary in the construction of restorations that are absolutely necessary and cannot be accomplished by other methods.

"If radiographs can be trusted in abnormal tissue study, they should be trusted to show normal tissue detail and repair; and if there be a defect, it is in showing too little rather than too much tissue involved." (Greeves.)

A radiolucent area shown upon the radiogram which does not fill in with sclerosed or scar tissue bone is a diseased area. These areas will not remain radiographically passive, but there will be regeneration or degeneration of bone. Whether or not we believe in apical or periodontal infection associated with systemic disturbances, we must all agree that all bone lesions are pathological and that they will spread and cause other cellular reactions of a detrimental character. If for no other reason than for the prevention of future complications, they should be removed.

Pulpless teeth should be removed if there is any periodontal

pathology. Pulpless teeth that approximate the maxillary sinus should be removed, because of the danger of maxillary sinus infection and often difficult diagnosis of apical involvement of the tooth.

All third molars should be removed where the pulp is involved because of the inaccessibility for root-canal work, and because their retention is of no great advantage.

Root-canal work in temporary teeth is not advisable.

Where pulps are removed aseptically and the organic portion thoroughly removed, the tooth is apt to remain free from apical disease even though the root-canal is only partially filled. It would seem, then, that the most important factors in root-canal surgery are asepsis and thorough mechanical cleansing of the root-canal.

In adopting a standardized classification of diseased teeth, and a routine method of treatment, it must be recognized that the ability of one dentist to obtain successful results is not equal to that of another dentist. Those who have made a special study of root-canal work will naturally excel in this work, and will be able to retain teeth which would be sacrificed in the hands of another dentist.

In a careful study of the results obtained by dentists, I would say not more than one per cent. of dentists are able to produce cures of perapical osteitis through root-canal surgery or apiectomy. Therefore, if this treatment is to be used it should be performed by specialists or those skilled in this particular work. The percentage of success obtained by specialists through root-canal surgery or apiectomy must depend entirely upon ability and choice of operations—attempting only those for which there is a very favorable chance of recovery. Considering the unfavorable results of treatment of these perapical areas through root or surgical means, it would appear wise to condemn all teeth the apices of which are infected.

FOCAL INFECTION

The principal sites of focal infection are:

(1.) Tonsils.

(2.) Alveolar process, including all forms of dental infection.

(3.) Accessory sinuses—(*a*) ethmoid; (*b*) sphenoid; (*c*) frontal; (*d*) maxillary. The normal sinuses are seen in Fig. 1.

(4.) Middle ear and mastoid.

(5.) Gastro-intestinal tract, including the gall-bladder and the appendix.

(6.) Genito-urinary tract, chiefly the prostate and seminal vesicles in the male and the uterine adnexia in the female.

(7.) Lymph-nodes and pus pockets in the skin, serous and mucous coverings, etc.

Metastatic Progress of Infection.—Invasion of infection from an oral focus occurs as follows:

(1.) By direct invasion of adjacent tissues.

(2.) By passage along the mucous and serous surfaces of the alimentary tract.

(3.) Through the blood and lymph channels, causing secondary foci in distant organs and parts of the body.

An apical infection may spread to adjoining teeth or may exist chronically over a long period and degenerate into a cystic condition involving a number of teeth. Periodontal diseases often invade adjacent tissues. This is particularly true of ulcero-membranous gingivitis, which spreads quickly to all parts of the mouth.

The germs and toxins may be carried directly by the saliva to the tonsils, pharynx, eustachian tube, and alimentary canal, causing secondary irritation and absorption, and giving rise to secondary foci. Conversely, other diseases throughout the alimentary canal, tonsils, etc., may cause infection of the mouth and teeth, and especially the gums and soft tissues, and make these areas more susceptible to attack by other organisms. There is just as much reason to believe that the teeth can be affected by diseased areas in other parts of the body, as there is reason to believe that these areas can be affected by the teeth. However, the matter of drainage plays a great part in the progress of the infection, and drainage is usually away from the teeth, excepting in hematogenous venous infection.

Infection from an area of open drainage is less apt to gain entrance into the blood or lymph streams. This form of metastatic infection usually occurs as a result of the closed type of infection within the tissues. The diffuse form is an example of the closed type which is absorbed freely into the blood and lymph streams. The circumscribed form is absorbed very slowly and the cyst may be completely immune to absorption at certain periods of its growth, depending upon its size and proximity to other structures.

The two main dental portals by which pathogenic organisms approach the pulp and subapical tissues, and thereby the lymph channels and blood stream, are: (*a*) the dentin, pulp, and root-apex, and (*b*) the gingival crevice.

EXTRACTION OF TEETH

While the radiograph has been the greatest aid in locating hidden areas of oral sepsis, it has also been the cause of needless sacrifice of many valuable teeth. The following cases will show that many infected areas may be removed by other means than extraction, such as treatment through the root-canal, prophylactic management best adapted to each individual case, and the cutting off of the affected portion of the root of the diseased tooth (apiectomy). When the health of a patient is impaired, it would appear wise to remove all apically infected teeth and those having marked periodontal disease, or those which would not respond immediately and without question to treatment. If a positive cure cannot be effected, then they should be removed. It is up to the personal skill of the operator to get the best results, and no result is good unless the infection is removed.

The extraction of infected teeth often causes marked general disturbances, such as fever, 101° F. to 104° F., general debility, soreness in glands and throughout the muscles, headache, stomach disorders, and all the other conditions which occur in systemic infection due to oral sepsis. These reactions may be slight or severe owing to the number and condition of the teeth removed or depending upon the resistance of the patient and the skill of the operator. General resistance may be lowered by fatigue, exposure, lack of proper nourishment, alcohol, pregnancy, diabetes, anæmia, and many acute and chronic diseases such as syphilis, typhoid fever, and tuberculosis. A closed wound without free drainage to the surface gives pronounced disturbance, and it is always a bad sign when a healthy clotting of the blood does not occur in the wound itself. There should be thorough curettage of these areas and thorough washing of the wounds and packing where it is not possible to obtain blood-clot, but there should be no curettage in those cases where it has been found necessary for good and sufficient reasons to remove the teeth during an acute condition. All the inflammatory foci about the teeth should be eliminated and the oral sepsis cleared up, there being proper

coöperation between dentist and physician during the entire period of treatment. Too many teeth should not be removed at one sitting, proper consideration being given to the resisting powers of the patient and the amount of the infection present. Rest and proper medication should be given between appointments when necessary.

After removal of a chronically infected tooth, even when there has been no local pain, discomfort, or soreness, other infected teeth in the mouth are very apt to become sore or acutely inflamed. This is particularly true of adjacent teeth, and may be due to the mechanical injury and inflammation incident to extraction. These exacerbations are always especially acute in those instances where the teeth have had to be removed during an acute condition, either in the mouth or elsewhere in the body, as in the joints, appendix, or tonsils.

IMPACTED TEETH

Definition.—An *impacted tooth* is one that is lying in such a position as to prevent or interfere with normal eruption, while an *unerupted tooth* is one not present in the arch, but which may later normally come into position. *Encysted teeth* is a term applied to impacted teeth surrounded with pressure absorption areas.

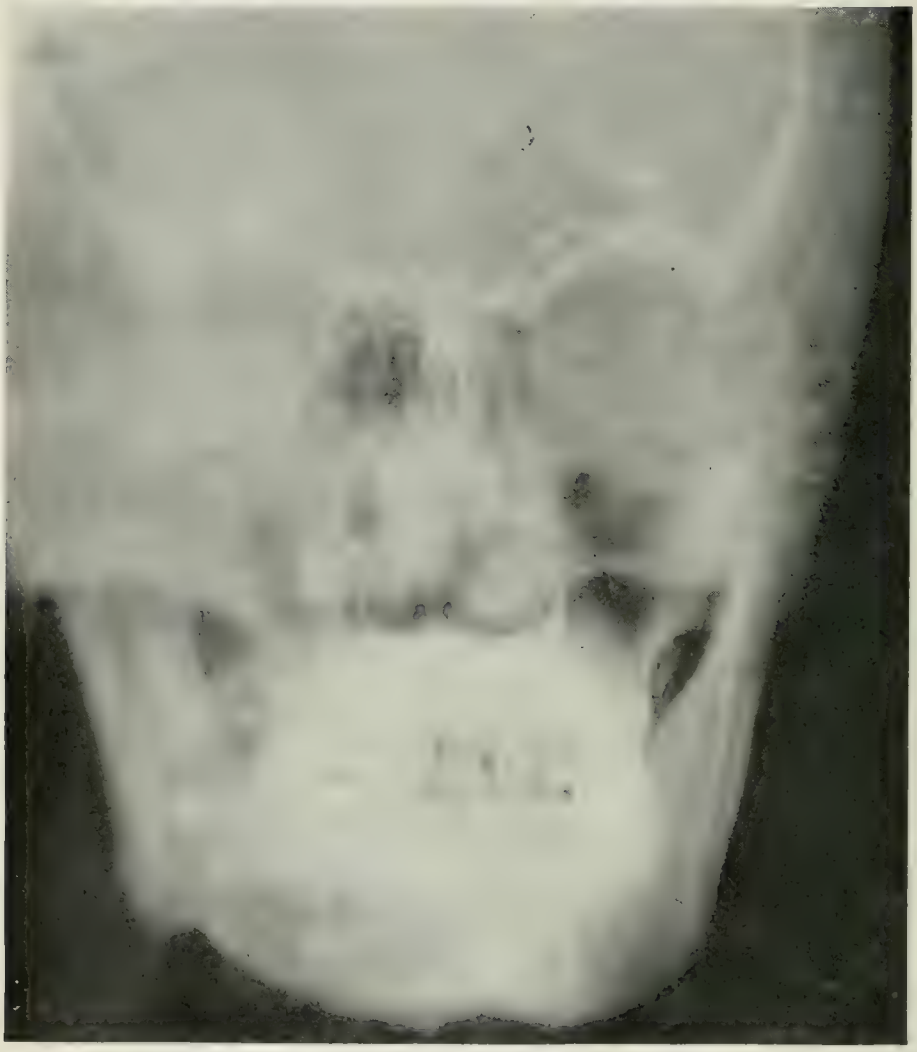
Location.—Any tooth in the arch may become impacted, but the most common impactions are the lower third molar, the upper third molar, and the cuspid teeth. Laterals and bicuspids are also impacted. Impactions of the other teeth are rare. The teeth may be lingually or labially displaced. The impaction may be slight, or deep, or far removed from its natural position. The tooth may be only partially impacted, being partially unerupted, or it may be entirely impacted or imprisoned in the bone structure. The impacted tooth may lie in undisturbed normal bone, with or without irritation, or pathological change of overlying soft tissue, or there may be alveolar absorption, cystic formation, etc. They may be found anywhere in the mandible, even to its inferior borders, or in the ramus, and anywhere in the maxilla, including the nasal and maxillary sinuses (Figs. 2 and 3). In a recent case seen by the writer the line of fracture passed close to an impacted third molar of the mandible (Fig. 4). Figs. 5 and 6 show an unerupted fourth molar.

Etiology.—The cause may be attributed to previous malocclusion

Fig. 2.

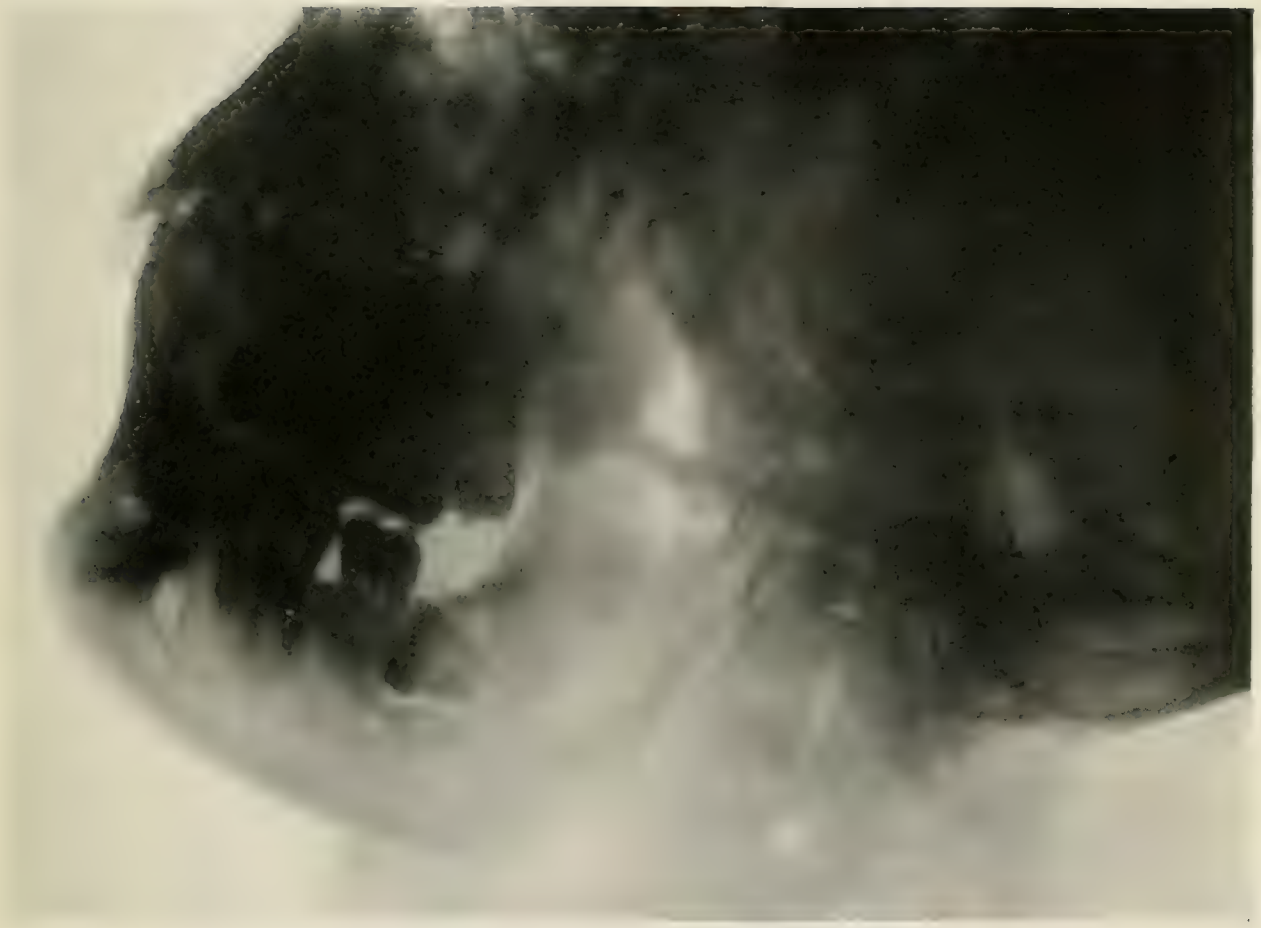
Lateral head view of unerupted third molar in the maxillary sinus.

Fig. 3.



Antero-posterior head view with unerupted third molar in the maxillary sinus.

FIG. 4.



Fracture of the mandible passing close to an impacted third molar.

Fig. 5.

Positive of unerupted fourth molar.

Fig. 6.

Negative of unerupted fourth molar.

of other teeth, misplaced tooth germ, or any of the causes of malocclusion.

Symptomatology.—There may be absence of irritation, pain, discomfort, reflex action, or systemic disturbance. Inflammation of overlying soft tissues, however, is very common, causing swelling, pain, etc. Injury or absorption of mesial teeth, cellulitis, trismus, false ankylosis, involvement of glands, reflex disturbance, and general system disturbances are common results.

Diagnosis.—Tooth missing from the arch, local pain or tenderness over an area, or swelling which may suggest an impacted tooth, are of important diagnostic purport. Valuable information is obtained from the radiograph in partial or complete impaction as follows: (1) Mesiodistal relationship (contact); (2) Labiolingual relationship; (3) Type of impaction (angular, vertical, horizontal, etc.); (4) Marginal ridge (depth in bone); (5) Interproximal space (space between impacted tooth and bone or adjoining tooth); (6) Occlusal plane (relationship to line of occlusion); (7) Size and shape of crown; (8) Number and inclination of roots; (9) Septum between roots; and (10) Septum between impacted tooth and adjacent teeth.

The *clinical symptoms* which may arise from unerupted or impacted teeth depend upon two factors; first, by the position of the tooth and its relationship to other structures and its proximity to other teeth, and second, by the presence of suppuration or infection.

While it is true that there are many local disturbances due to irritation, from impacted and unerupted teeth, yet these conditions are greatly overestimated as regards their general systemic effects. I do not believe these conditions often give general disturbances, *per se,* but as a result of irritation and when present these results can be discerned by careful examination. In but rare exceptions do we find these conditions giving rise to general complaint without suppuration or by some local manifestation of pain or discomfort, such as soreness, neuralgia, etc.

A pericronal area of bone absorption around an impacted tooth does not mean infection. However, if these areas of absorption communicate with the mouth cavity, there will be infection, sooner or later, as a result of contamination.

I do not believe that all impacted teeth should be removed because

of danger of systemic disturbances any more than I believe all pulp stones and areas of osteosclerosis should be removed when not giving local disturbance. I do believe, however, that many impactions should be removed purely from a local standpoint to prevent crowding of the dental arch, danger to adjoining teeth, etc., and I believe all impacted teeth showing pockets or bone absorption where infection can occur, should be removed. I do not believe all impactions should be removed, as to do so would cause much mutilation and discomfort without benefit to patient in many cases. Many instances may be cited where impactions have remained undisturbed for years without any general disturbance or local manifestation.

PERIAPICAL DISEASES

Definition.—Periapical diseases are inflammatory disturbances involving the periodontal membrane and alveolar bone tissue surrounding the apices of roots of the teeth.

Clinical Classification.—Acute forms: (1) Acute apical pericementitis or acute pericemental abscess; (2) Acute periapical alveolitis or acute periapical alveolar abscess. Chronic forms having: (1) No discharge; (2) Discharging into blood and lymph streams; (3) Discharging through fistula into mouth or externally; and (4) Discharging through root-canal.

Etiology.—Usually acute apical abscesses are preceded by pericementitis, and followed by chronic conditions, but the acute abscess may develop without previous disturbance. A chronic abscess may also become acute at any time. The septic and non-septic causes of apical pericementitis and periapical alveolitis are:

(1.) Bacteria associated with decomposition of pulp and pressure of gases evolved.

(2.) Organisms introduced into canal by instrumentation through lack of aseptic handling.

(3.) Infection from adjacent areas.

(4.) Hematogenous infection.

(5.) Trauma.

(6.) Wedging and moving teeth.

(7.) Pressure and irritation of filling.

ACUTE APICAL PERICEMENTITIS OR ACUTE PERICEMENTAL ABSCESS

Symptomatology and Diagnosis.—There is marked tenderness of the periodontal membrane and gingiva. There is a sensation of irritation or itching, which is relieved by pressure or biting upon the teeth. In the later stages there is congestion and elongation of the tooth, and occlusion is then painful. The inflammation may become localized or spread throughout the entire membrane or to adjacent teeth. There is often an involvement of connective tissue of lips and cheeks, accompanied by swelling and pain. If not aborted there is localized formation of pus. Position of swelling, location of pain, knowledge of devitalized teeth, history of trauma, etc., are deciding factors in making the diagnosis. Radiographing is of no value, except as an aid in eliminating the possible involvements, such as bone absorption, etc.

ACUTE PERIAPICAL ALVEOLITIS OR ACUTE PERIAPICAL ALVEOLAR ABSCESS

Symptomatology and Diagnosis.—Acute periapical alveolitis can only follow acute periapical pericementitis or acute pericemental abscess, whereas acute periapical alveolar abscess may follow acute disturbances or be due to a subacute involvement of the chronic variety. These conditions are so closely related that clinically there may appear no difference in symptoms.

Inflammation begins suddenly and is of short duration, and the symptoms are severe. The tissue destruction is usually very limited, leaving no permanent effects if controlled. Inflamed tissue is red, swollen, painful, and hot. Swollen area is at first dense and later becomes more fluctuating with the formation of pus. Pus usually forms after twenty-four hours, but the time may be longer, and with pus formation pain is more intense and throbbing in character.

Pus will escape through tissue or avenue affording least resistance. It may form a local sinus or it may penetrate the tissues and escape at some distant point, such as the nose, cheek, sinus, throat, etc. Usually the pus finds an exit through the external alveolar plate and into the mouth. The tooth or teeth affected are more loose than surrounding teeth, and elongated further out of socket than in case of acute pericementitis. Since inflammatory action precedes pus formation, it is possible to determine where the abscess will point or

discharge by noting site of greatest swelling and coloration (Fig. 7). A sudden termination of the acute conditions without an apparent opening for the exit of pus, is suggestive of exit into a sinus or other unusual places. General symptoms are chill, irregular temperature, from normal to 103° F. or 104° F., constipation, coated tongue, dull pains in head, occasional vomiting, leucocytosis 10,000 to 20,000, and general exhaustion.

CHRONIC PERIAPICAL DISEASES

Symptomatology and Diagnosis.—Usually there is no local pain. There may be a sensation of uneasiness, fulness, or uncomfortable feeling and reflex pains. Condition may become acute at any time, if there is interference with drainage. In upper teeth palpation on apex usually is productive of slight pain, due to closeness of area to surface. In lower teeth this is not usually found to be the case. There may be a hard swelling or distention of alveolar plate. There may be either a local fistula or a distant fistula. Pus may be found in canal, alveolar, socket, fistula, sinus, etc. Tooth usually does not respond to percussion. Radiographing is indispensable, as it will disclose the amount of bone absorption. Subjective general symptoms of systemic disturbances may usually be obtained from careful questioning of the patient.

Types of periapical osteitis as shown by the radiogram are (1) Circumscribed; (2) Diffuse; and (3) Cystic.

(1.) The *circumscribed type* shows a more or less regular outline of the periphery of the area of bone absorption with a condensation of the surrounding bone, showing Nature's effort to wall off the effects of the toxins. These areas may range in size from a pin-point to a lentil.

The *diffuse type* of alveolar absorption shows usually a very irregular outline of the periphery of the area of bone absorption. The larger the area the more irregular the periphery outline. There is no condensation of the surrounding bone shown in this type. These areas may range in size from one-quarter of an inch to several inches.

The *cystic type* shows the area of alveolar absorption surrounded by a dense light line which represents the fibrous capsule of the cyst. These may range in size from a ten-cent piece to half a dollar.

Periapical infections are the most virulent of all the forms of

Fig. 7.

The abscess from a lower tooth is "pointing" externally in the angle of least resistance. Every effort should be made to prevent such cases from opening or being opened externally. A drainage tube, attached to the mouth by adhesive plaster, may often be used to advantage for the home use of cleansing the abscess through the tube by a proper wash.

oral sepsis in giving rise to systemic diseases for the reason that the inflammation is located in bone, which does not possess a good blood supply, and that there is no means of expansion when inflamed on account of the dense surounding tissues. This is in marked contradistinction to the soft tissues of the gums in which the periodontal type is located. A periapical infection may spread to adjoining teeth or may exist chronically over a long period of time and degenerate into a cystic condition involving a number of teeth. Toxins from this circumscribed form are absorbed very slowly, and the cyst may be completely immune to absorption at certain periods of its growth, depending upon the size already reached and its proximity to other parts.

Chronic alveolar abscesses do not as a rule give rise to a single disagreeable local symptom, and thus easily escape the attention of both patient and physician. It is only when the condition becomes acute through the formation of pus that the symptom even of pain appears.

Systemic disturbances caused by periapical infection are usually found to be due to the tooth least suspected by the patient, and the one which most often has given the least amount of discomfort. It is quite common to have patients present themselves for examination to determine the source of systemic disturbances and to request radiograms of certain teeth which have given them pain. They are often extremely skeptical when told after a complete X-ray examination of all the teeth that the source of the trouble is located in a tooth entirely unsuspected by them. In such cases, when they would not appreciate the report of the bacteriologist or a view of the radiographs, I have found the most convincing argument is to give the patient an opportunity of catching the fetid or disagreeable odor arising from the extracted tooth.

Contrary to the opinion of some authorities, that most periapical infections are found in old age, I believe most cases occur in earlier years, although the condition may persist for a long while, and may occur at any age. It is not uncommon to find instances of periapical infection in children of from three to five years of age, or it may be discovered at the other end of life in an octogenarian who has supposedly had all of his teeth removed, but where the root of one of the teeth has been left behind and has given rise to an area of focal infection from which a systemic condition has arisen.

One of the most frequent causes of this type of infection is dental work. An infection may run its course for years in the root-canal and at the apex of a tooth, when there exists local drainage through decay and open canal or through fistula, without appreciable systemic disturbance, but just as soon as a filling is inserted, the canal plugged, or the fistula closed, there immediately appear definite and marked systemic disturbances, which may disappear when the drainage is reëstablished.

A large proportion of pulpically treated teeth are a source of oral sepsis. Some mouths have such a power of resistance against the invasion of bacteria and the consequent formation of abscesses that even defective and poor dental-work does not give rise to periapical areas of infection, while in other instances this condition occurs even with the following out of most careful, aseptic root-canal surgery and perfect root-filling.

PERIODONTAL DISEASES

Definition.—A periodontal disease is any disturbance of the periodontal tissues, or the tissues surrounding the tooth-root, which has its origin in the gingiva, or gums, or occurs as a result of pericementitis.

The term "pyorrhœa," which is quite widely used in speaking of these conditions, has given rise to a great deal of confusion; as pyorrhœa, or Riggs's disease, is described as a loosening of the teeth associated with continued suppuration. There are various stages of periodontal involvement, and the initial lesion is not associated with suppuration, but only simple inflammation. The term "pyorrhœa," therefore, does not convey any idea as to the state of involvement of the tissues.

Classification.—(1) Recession is an irritation of the gum margin and underlying tissues, resulting in an exposure of the cementum. It may be: (*a*) *Traumatic recession,* in which case the recession of the gums is induced by a mechanical abrasion, and is usually limited to the labial or buccal gingivæ; (*b*) *Senile* or *atrophic recession,* a low grade of tissue and bone absorption, without apparent inflammation, which accompanies advanced age; it is generally evenly distributed throughout the entire mouth; and (*c*) *Pathological recession,* where the recession accompanies resorption of the underlying alveolar

process and the gums are affected more or less uniformly upon the entire tooth, the gum being swollen and reddened.

(2) Gingivitis is an inflammation of the gum margin, of which the following are the chief varieties: (*a*) *Acute traumatic gingivitis,* due to a local injury.

(*b*) *Systemic gingivitis,* in which one or more teeth may be involved, or it may be distributed throughout the entire mouth. The symptoms are usually those of soreness or local pain, and may be due to auto-intoxication, malnutrition, metal or drug poisoning, or any general systemic disturbance. In the latter instance the gingivæ usually show the first local manifestations, and a careful mouth examination often leads to the discovery of *aciditis,* blood changes, nephritis, heart lesions, etc., in their incipiency.

(*c*) *Chronic gingivitis* is the result of continued irritation to the gums. There is usually free bleeding of the gingivæ, and a definite pocket formation, there being little or no pain.

(*d*) *Gingival abscess* is an acute inflammation of a gingival pocket, with the appearance of pus.

(*e*) In *Anæmic gingivitis* the gums are usually tight about the teeth without deposits, and there is often bone absorption without the appearance of inflammation. The gums are colorless and almost white. The roots of the teeth are usually greatly exposed. Talbot believes that this always denotes some systemic disturbance.

(*f*) *Ulcero-membranous gingivitis* (*Vincent's angina*) is an infectious and contagious disease of the mouth which attacks the gingivæ, producing characteristic ulceration in which a spirillum and a fusiform bacillus are present.

Nomenclature.—Ulcero-membranous gingivitis is a term suggested by Greeves. It is also known by other terms, such as acute ulcerative gingivitis, acute ulcerous gingivitis, phagedenic gingivitis, Vincent's periodontal gingivitis, trench mouth, and Vincent's angina. The term Vincent's angina, however, is usually understood to mean the manifestations of this form of disease in the tonsils and throat of a more serious nature.

Location.—This disease is most frequently found in the mouths of young people between the ages of 16 and 25, although age is no barrier, and it may appear in the very young or very old. A common form is where it is distributed throughout the mouth,

involving the gingivæ surrounding most, if not all, of the teeth; but it may appear around a single tooth. It often appears in the region of a partially erupted third molar under the flap of gum tissue, and there are instances of its occurrence unilaterally involving a number of teeth. The usual location is the gingivo-buccal border of any tooth, and especially that of the first and third molars.

Etiology.—Ulcero-membranous gingivitis is most frequently found in ill-kept mouths where sufficient care has not been exercised in cleaning the teeth, although its contagious and infectious character renders mouths with only slight gingival irritation particularly susceptible to attack through direct contamination with the specific organisms. The contagiousness of the disease was well illustrated by its occurrence in the mouths of large groups of men during the war.

The disease may be contracted through food, utensils, dishes, drinking glass or cup, kissing, or any means of salivary contact. The specific organisms isolated from these ulcers are fusiform bacilli and Vincent's spirochætes. The organisms are of the anerobic type, thriving best in the absence of oxygen. These germs are, of course, associated with other forms of mouth organisms, such as the pyogenes group, and any involvement within the mouth is therefore a mixed infection. Positive identification of the fusiform bacilli and Vincent's spirochætes is made through smear upon a glass slide, preferably by the India-ink method, and the diagnosis of ulcero-membranous gingivitis confirmed.

These germs may be found even in healthy mouths, and the virulency of the organisms therefore depends upon environment. The most severe symptoms are those associated with involvement of deep pockets and flaps of tissue over unerupted and impacted teeth. There may be pain, where the disturbance is due to slight gingival irritation or gingival pockets, with slight but local pain, if there is an extraction of a tooth, or a new field of tissue opened up for the invasion of the infection, there is immediately developed a more serious form of disturbance and a more virulent strain of the organism.

The bacillus fusiformis and Vincent's spirochæte are often associated with the most destructive and fatal forms of disease, such as gangrenous stomatitis and necrosis, cancrum oris, noma, leukæmia, etc.

Symptomatology.—Ulcero-membranous gingivitis is characterized

by the appearance of a sensitive and very painful superficial ulcer, which is of an irregular shape, and is covered by a whitish-gray membrane which is easily removed. The bleeding is usually profuse. The onset of the disease is sudden, and is accompanied by fetor, salivation, temperature 100° F. to 102° F., swollen glands, mental depression, loss of appetite and general malaise. The leucocytes are usually below 10,000, as compared to a high count in pyogenic infections, such as tonsillitis, etc.

In the acute stage pus does not appear, excepting through mixed infection of the pyogenic group of bacteria. Fusiform bacillus and Vincent's spirochæte, which have become of a less virulent strain, are often present in the chronic form of periodontal disease, and where these organisms predominate the disease may then be considered as a chronic form of Vincent's ulcerative gingivitis. Greeves calls attention to this form of the disease and its likeness to other periodontal affections.

While ulcero-membranous gingivitis is primarily a necrotic or pseudo-membranous disease associated with gingivitis and periodontoclasia, it is best differentiated from other periodontal diseases by the following:

Ulcero-membranous Gingivitis	Other Periodontal Diseases (Gingivitis, Periodontoclasia, etc.)
(1.) Usually a disease of young people.	(1.) Usually a disease of middle-aged and old people.
(2.) Onset sudden.	(2.) Onset usually slow.
(3.) Very painful.	(3.) Usually not painful.
(4.) Characteristic superficial ulceration.	(4.) No ulceration.
(5.) Usually swollen glands.	(5.) Usually no swelling in glands.
(6.) Pronounced systemic disturbances.	(6.) Slight systemic disturbances.
(7.) Fever and temperature, 100 to 102.	(7.) Temperature normal and no fever.

Ulcero-membranous gingivitis is frequently mistaken for periodontal diseases, and at times for syphilis or other infectious diseases. It is often associated with other like disturbances in the fauces and tonsils. The disease, as already stated, when located in the fauces and tonsils is called ulcero-membranous angina, canciform or diptheroid angina, but is best known as Vincent's angina.

(3) Periodontoclasia, the next periodontal disease to be considered, as the name implies, is a breaking up or detachment of the tissues surrounding the teeth. The varieties are (*a*) non-suppurative,

where the periodontal tissue is separated from the cementum without the macroscopic formation of pus; (*b*) suppurative, where the principal tissues are separated from the cementum with the formation of pus; (*c*) alveoclasia (alveolar periodontoclasia), in which there is a resorption of the alveolar process without separation from the cementum and without macroscopic pus formation.

(4) Cementoclasia or pericementoclasia is a disintegration of the cementum, and is usually accomplished without loss of the overlying gingival tissues.

Etiology.—The causes of periodontal disease may be primary or exciting, and secondary or predisposing. The primary factors are those which are directly responsible for the occurrence of the disease, such as trauma, tartar, malocclusion, systemic disturbances, etc. The secondary factors are those which influence the progress of the disease after the primary lesion, such as parasitic invasion, systemic disturbance, malocclusion, etc.

Exciting and predisposing causes of periodontal diseases are:

(1.) Local irritation or mechanical causes, such as: (*a*) Soft deposits; (*b*) Hard deposits; (*c*) Denuded cementum; (*d*) Abnormal tooth form; (*e*) Defective contacts; (*f*) Traumatic occlusion; (*g*) Defective occlusal restorations; (*h*) Defective gingival restorations or perforations of root; (*i*) Crowns, bridges and prosthetic appliances; (*j*) Improper brushing, use of tooth-picks, etc.; (*k*) Clasps, clamps, ligatures, etc.; (*l*) Cavities; and (*m*) Unsanitary mouth conditions.

(2.) By direct invasion of infection from adjacent parts: (*a*) Spread of infection from adjacent teeth; (*b*) Invasion of infection from other parts of mouth; and (*c*) Contamination from parts adjacent to mouth, such as tonsils, maxillary sinus, etc.

(3.) Systemic conditions which increase the susceptibility of the tissues to infection and irritation: (*a*) Acute infectious diseases; (*b*) Chronic infection and diseases; (*c*) Diseases of the blood; (*d*) Nutritional disturbances; (*e*) Pregnancy; (*f*) Alcoholism; and (*g*) Mineral and drug poisoning, as lead, mercury, potassium iodide, etc.

The initial periodontal disease is usually due to one primary factor, or there may be more than one primary factor involved. As the disease progresses, however, we usually find one or more secondary factors or contributing causes which increase the susceptibility of the tissues to bacterial invasion. Improper cleansing of the teeth

because of local defects or neglect is one of the most frequent causative factors of these periodontal disturbances. The influence of secondary factors is of great importance, as acute local injury in normal mouths of healthy individuals is usually rapidly repaired; but in the mouth of a patient with diabetes, in pregnant women, and in many systemic disturbances, the tissues will show progressive pathological changes. Local irritation causes very little disturbance in some mouths, whereas in others there is great disturbance, depending upon the susceptibility of the tissues from other contributing causes. Tartar is one of the most frequent local causes of periodontal disease.

While general systemic disturbances play a great part in the progressive pathological changes of periodontal disease, their effect is usually considered secondary to some predisposing cause. They render the tissue more susceptible to local irritation.

Authorities agree that infection is not the cause of periodontal disease, but that it is a secondary factor. Infection is always present in all periodontal disturbances, and plays an important part in the pathological tissue changes. In the examination of superficial pus and exudate from these pockets there are usually found *Streptococci, Pneumococci, Diplococci, Staphylococci,* bacilli, especially the fusiform variety, and *Spirochetes andamebæ.* Examination of pus from the deeper areas usually show *Streptococcus viridans, Streptococcus hemolyticus, Staphylococcus aureus* and *albus* and the *Amebæ. Streptococci* usually predominate in numbers, and are often in relatively pure culture. Vincent's spirillum and the fusiform bacillus when found in overwhelming numbers or pure culture are indicative of ulcero-membranous gingivitis, although these organisms are frequently found in small numbers in pus obtained from pockets around the teeth in other forms of periodontal disease.

Pus pockets in the periodontal tissues as a result of inflammation around the teeth, harbor organisms which constantly pass into the alimentary canal giving rise to secondary foci of infection. Fortunately, the harmful effects of virulent organisms are destroyed or attenuated by the oral, gastric and duodenal secretions unless there be long continued irritation from excessive amounts of toxin, or a lowered resistance of the tissues, while, as we have seen, freedom from systemic effects is the exception in the apical variety. It is the rule to find mouths with any number of periodontal pockets with little

or no systemic disturbances other than that of malaise. Were this to be observed in but exceptional cases it might be attributed to the resistance of the patient, but as it is a common occurrence it would seem that the natural forces of Nature were better able to protect itself than in the periapical variety, where the organisms gain access to the lymph- and blood-channels.

From a close observation of the results of different types of infection arising from oral sepsis, I have noticed that the systemic disturbances are usually more severe as a result of the apical type than from the periodontal or open drainage variety. Although the periodontal type is more often overlooked as a source of systemic disturbances because of light radiographic evidence of disease, gingivitis, even though of only slight involvement, and radiographically negative, may prove to be a most harmful focus when associated with a large number of teeth or even one area in a susceptible case.

The percentage of the cases affected with the periodontal type of infection increases with the age of the patient, and rarely occurs in the mouths of children up to fifteen years of age. General systemic effects are accompanied with all the signs of inflammation observed elsewhere in the body, along with pain in the teeth, soreness and swelling of the gums, bleeding from the gums, especially after the cleansing of the teeth with a tooth-brush, unpleasant odor to the breath, etc. Stiffness in back of neck, pain in the back, eyes, ears, and nose, throat trouble, muscular, neuralgic, and nervous disturbances, chronic conditions of the maxillary sinus, throat, tonsils and glands, may all fail to respond to treatment by reason of some foci of infection within the mouth. They recur without apparent cause, but disappear upon proper treatment of the oral sepsis. The radiogram will best reveal the extent of the condition, and whether or not there may not be a coexisting apical involvement of one or more teeth.

Periodontal diseases often invade adjacent tissues. This is particularly true of ulcero-membranous gingivitis due to the fusiform bacillus and Vincent's spirochætes, occurring especially in the mouths of young children.

Successful treatment depends upon coöperation of patient, as it will be necessary for the patient to carry out a systematic prescribed course of treatment with regularity. This treatment must be con-

tinually and permanently followed or the case will drift back into the former diseased condition. Periodontal treatment for teeth with septic apical conditions is contraindicated, as good results cannot be expected. All apical disease must be eliminated.

DIFFERENTIAL DIAGNOSIS

PULP	PERIODONTAL MEMBRANE
In the earlier stages the pain is distinctly paroxysmal and later lancinating. The pain increases with excitement, exercise or assuming a recumbent position.	The pain is not paroxysmal, or lancinating. It is localized, steady, dull, or throbbing. Pain remains more or less constant without regard to excitement, exercise or recumbent position.
The tooth is not elongated and does not strike first in occlusion.	The tooth is raised in its socket and strikes before the other teeth occlude.
Percussion does not give pain, and may give temporary relief.	Percussion induces pain.
The tooth is responsive to thermal changes. In the early stages before congestion, heat and cold give pain. When congested, cold relieves and heat gives pain. When putrescent, no response to cold, while heat gives immediate pain.	There is little reaction to temperature changes. Cold usually gives relief, while heat may slightly aggravate.
There is no swelling of the soft tissues about the tooth and no tenderness to pressure except in acute condition when membrane also becomes involved.	The tooth becomes very sore. Light pressure may relieve temporarily, but soon pain becomes intense. Swelling is common.
Sometimes difficult to locate exact tooth, as pain is reflex.	Tooth is easily located, as pain is local.
Tooth usually devitalized or shows caries.	Tooth usually vital, and defects of no consideration.

TREATMENT OF PERIODONTAL DISEASE

Class I. Gingivitis. No bone absorption; no pocket.
II. Slight bone absorption and pocket.
III. Bone absorption of marked degree, but involving less than half the length of root of tooth.
IV. Bone absorption extending more than half the length of root of tooth.

Attention must be given to all defective dental work and defective conditions, such as open contact, overhanging fillings, crowns, irritation bridges, cavities, etc.

In cases where more than half of the alveolus has been absorbed or destroyed and the cementum exposed, the prognosis, as a rule, is unfavorable.

Occlusion is to be considered in every case, and if it cannot be corrected, then prognosis is usually doubtful.

Approximal support of periodontally diseased teeth gives a more favorable prognosis.

Cutting or injuring the cementum in treatment is detrimental.

Surgical removal of overlying diseased tissue will eliminate deep pockets and give more favorable prognosis.

Very little dependence should be given to drugs, mouth washes, and cure-alls. Mechanical and surgical treatment and proper after-care are the secrets of success in this type of disease.

Diet and general health must be considered.

EXAMINATION OF THE PATIENT

Most patients visit the dentist because of some local complaint, such as pain and swelling, for restorations in the mouth, or because they have been referred to the dentist by the attending physician with the object of discovery or removing focal points of inflammation. It is the duty of the dental surgeon to obtain full information from the patient regarding not only the local complaint, but regarding symptoms of all general disturbances, and to call attention to conditions which are detrimental to the patient's health. The presence of oral sepsis and other mouth conditions which may affect the general health should also be made known to the family physician by the dental surgeon, whether the patient has been referred to him or not.

The examination should be conducted in a routine manner, recording the results of the examination on some suitable printed chart, so that an accurate and positive diagnosis may be made, which can be quickly consulted. The following plan may be used:

(1.) Complaint.

(2.) History.

(3.) Manifestations of pain.

(4.) Physical examination: (*a*) Ocular; (*b*) Percussion and palpation; (*c*) Exploration; (*d*) Color; (*e*) Conductivity of temperature; (*f*) Transillumination; (*g*) Radiograms; and (*h*) Pulp testing by electric current.

(5.) Bacteriological examination.

(6.) Pathological tissue examination.

(7.) Biological and chemical tests: Wasserman reaction.

(8.) Differential diagnosis.

(9.) Treatment recommended.

(1.) *Complaint.*—In many cases there is a complaint for which the patient seeks relief, and this condition should receive our first consideration. Local pain or discomfort, an attempt to trace general systemic disturbances to the mouth or teeth, or both local pain and general disturbance, may be brought out by proper questioning. While it is difficult in many cases to convince the patient of the advisability of a complete mouth examination, it is the duty of the dentist to solicit information regarding the general health, to examine the entire mouth and to call the attention of the patient to the necessity and advantages of a complete examination. A full description of the complaint of which the patient complains should be obtained in every instance.

(2.) *History.*—Very often the matter of diagnosis is facilitated by some pertinent data obtained in taking the history of the patient. Inquiry along the following line may produce valuable information:

(*a*) *Heredity,* inquiring into such conditions as syphilis, tuberculosis, anomalies (hair-lip and cleft palates), and rickets.

(*b*) *Use of drugs and chemicals,* as mercury, iodine, potassium iodide, acids, iron, phosphorus, and bismuth.

(*c*) *Occupation,* as match factories, manufacturing of acids, antimony, handling of lead, mercury, and bismuth, glass and sand blowers, and candy factories.

(*d*) *Previous or present disease,* such as syphilis, tuberculosis, rheumatism, colds, sinus involvement, malaria, rickets, fevers, and malnutrition, with lack of proper vitamines.

(*e*) *Habits:* Pipe smokers, use of tobacco in any form, chewing of grain (actinimycosis), use of abrasive tooth powders or pastes, biting off threads (lead poisoning), and wooden tooth-picks.

(3.) *Manifestations of Pain.*—Pain as exhibited by the patient is the most valuable diagnostic expression of oral disease. The outward manifestation of pain is by no means a guide to its actual intensity, as pain largely depends on the psychic condition of the

patient (Goldscheider). Patients are often unable to give an intelligent description of a pain unless properly questioned.

The expression of pain may be divided into objective and subjective symptoms. The objective symptoms are those produced by temperature, chemicals, percussion, palpation, and the electrical test. The diagnostic reaction noted may be an expression of pain by the patient. The patient may cry out, jump, or wince. The subjective symptoms are those giving no outward manifestation and described by the patient.

The examination should be begun by having the patient point out the location of the pain and the exact spot at which it first appears. Question the patient as to whether the pain is constant or intermittent or paroxysmal, local or radiating; whether or not the pain varies in position or intensity; whether or not it is more severe at certain times or appears only at certain times; whether or not it is influenced by certain actions such as eating, drinking, laughing etc. Question the patient as to the nature of the pain, such as boring, drawing, throbbing, lancinating, jumping, etc.

Pseudomanifestations of pain are those obtained from excitable and nervous patients and those susceptible to suggestion.

(4.) *Physical Examination.*—(*a*) *Ocular:* The general condition of the mouth should be noted, as to whether there is apparent oral sepsis, improper care of mouth or neglect, and defective dental restorations. Examination of the gums and mucosa should disclose following information:

- Condition
  - Normal
  - Dry
  - Viscid
- Appearance
  - Normal pink
  - Pale
  - Red
  - Purple
- Recession
  - Slight
  - Medium
  - Marked
- Gingival border
  - Normal
  - Thick
  - Loose
  - Ragged
- Periodontal area
  - Hypertrophy
  - Syphilitic
  - Ulcero-membranous gingivitis
  - Periodontoclasia

The presence of calculus should be noted, and, if present, as to whether hard, medium, or soft, and its exact location.

The general condition of the teeth should be studied with regard to the following conditions: Absence of any teeth; impactions; abnormal teeth; supernumerary teeth; whether deciduous or permanent sets; caries; abrasion; erosion; defective contact; malocclusion; arch; and occlusion.

The character of dental restorations and operations should be noted to obtain following information: Healing of wounds; crowns and bridges; plates; and fillings, especially whether the margin, contact, and occlusal restoration are defective or not.

A bad odor of the breath may be determined on approach to the patient. The examination of the saliva should disclose:

Quantity	Normal Excessive Subnormal	Odor	Normal Fetid
Appearance	Normal Ropy Watery and thin		

The reaction of the saliva, which is normally neutral or slightly alkaline, and any excretions, when present, should be tested with litmus paper.

If a rash be present, its distribution and character should be carefully noted.

The examination of an ulcer should determine the character of its base, edge, and the condition of the surrounding tissue, and whether or not there is any discharge. Examination of benign swellings and tumors should show position, character of structure in which it is located, and size.

(*b*) *Percussion and Palpation.*—Percussion is the least valuable diagnostic sign in the examination of teeth, and is performed by striking the tooth with an instrument, producing a dull sound upon a pulpless or purulent pulp, and a clear sound upon a vital tooth.

Palpation is used to determine if pressure upon the crown vertically produces pain in the apical region, or whether pressure upon the mesial, distal, buccal or lingual surfaces give pain. Pain in the

apical region in response to vertical pressure is indicative of apical involvement, and pain upon lateral pressure is indicative of periodontal or pericemental involvement. Quite often palpation will give response to pain when pressure is made over the apex or other sites of involvement. Digital palpation will detect any local soreness, character of referred pain, or the crepitation of fracture.

(*c*) *Exploration.*—All surfaces of the teeth should be carefully gone over by making use of explorers and mouth mirrors, and record made of cavities, erosion, exposed cementum through recession of gum, tartar and calculus, abrasion, etc. The teeth should be examined in systematic and regular order and all surfaces studied.

Openings or fistulas in soft tissue should be recognized and explored with probe if possible. Alveolar socks of teeth bordering maxillary sinus that have had chronic bone involvement should be explored with probe to determine if there is opening into sinus. A probe passed into swollen areas, cysts, tumors, etc., will disclose the character of contents of same, whether fluid, blood, pus, solid, etc.

(*d*) *Color.*—Color of teeth is not always an indication of the condition of the pulp, but any dark tooth is always suspicious until proved otherwise. Discoloration may be superficial and caused by tobacco, chemical and food stains, filling materials, or it may be due to leakage of fillings through recurrent caries. Death of the pulp usually produces various shades of darkening of the tooth. The color of the soft tissues is an indication of the condition as to whether normal or inflammatory. The color of a gingival irritation is often indicative of its cause, as in lead poisoning, mercury poisoning, etc.

(*e*) *Conductivity of Temperature.*—In the early stages of pulp involvement before the congestive stage has been reached, cold and heat both produce pain. When the pulp has become congested cold relieves and heat gives pain; when the pulp becomes purulent there is no response to cold, and heat gives immediate pain; when the pulp dies neither heat nor cold give pain, but continued heat will produce a response from the pericementum.

There are a number of ways of applying heat or cold, but I prefer to use an ordinary hypodermic syringe with ice water or hot water and apply directly to the tooth or cavity in question, or a piece of cotton dipped first into cold water and then into hot may be applied to a suspicious area.

(*f*) *Transillumination.*—Transillumination (*Frontispiece*) is a valuable aid in making a diagnosis of mouth conditions, but it has its limitations. In the dark room a small incandescent lamp when placed in the mouth may disclose many pathological conditions if present.

In the examination of the maxillary sinus, transillumination is most useful. This is accomplished by placing the light in the patient's mouth and closing the mouth. The light is transmitted through a normal antrum and shows beneath the eye, while on the diseased side there is a shadow or an opacity, which is not normal. Transillumination may be misleading, as the bones on one side may be thicker than on the other side. Transillumination is more satisfactory for persons whose tissues are not thick and dense, as in the case of children.

The frontal sinuses may be transilluminated by placing the light just above the inner corner of the eye and covering the light with the hand, so that the outline of the sinus may be clearly seen. The diseased area will appear opaque.

Transillumination will not disclose areas of perapical infection about the teeth. Periodontal infection may be shown by transillumination where the periodontal membrane is separated from the cementum and the root discolored. The diseased area will appear dark.

(*g*) *Radiograms.*—I advise full mouth radiographs in the great majority of cases. No matter how careful the operator, there are times when he will be mistaken without radiographing all of the teeth. There is every advantage in full set cases, as they serve as a record, relieve the operator of any uncertainty and ultimately save time. I find, however, that it is not practical to take full cases for every patient, as in some instances radiographs are not absolutely necessary, and in many cases partial views will answer the purpose. In addition to the full mouth set I prefer two lateral views, one for each side. Postero-antero views are sometimes needed, as well as stereoscopic films and plates. The examination chart is useful in showing complete diagnosis in connection with full clinical data. Radiograms also prove valuable as a record, and should be filed as a part of the diagnostic record for future reference.

Since there are such a large number of points of diagnosis covered by a radiographic examination, I do not advocate making a record

of this information, but rather using the radiograms in connection with other information to record a proper diagnosis, and then keeping the radiograms with all the other information where they can be easily referred to.

In oral diagnosis the radiogram is a valuable diagnostic aid when used as an adjunct to other clinical findings. There is no other single factor which will give so much valuable information, or which may be so deceptive as the radiogram. When used to supplement other clinical methods of examination, radiograms are indispensable in most cases, but when considered without other clinical factors and findings, they are practically useless.

The radiogram is a shadowgraphic or skiagraphic view, showing the varying degrees of density of the substances through which the rays pass before acting on the sensitized film. The more dense the object through which the rays pass the less the resulting action upon the photographic plate, and consequently the lighter the object shown upon the finished radiographic film; and, conversely, the less dense the object through which the ray passes, the darker the resulting area shown upon the finished film. In a print, therefore, what is light becomes dark, and what is dark becomes light. The illustrations in this paper are printed in the manner they appear on the original plate or when examined on the fluoroscopic screen. This is contrary to the ordinary method, but is the scientific way in which to study and read radiograms.

The ideal use of the radiogram for dental purposes requires:

(1.) It be produced by those who are familiar with the requirements of dental diagnosis, who can best choose the kind or size of the film; who understand correct angulation to bring out the suspicious area, and those who know the length of exposure advisable in order to not cause injury to the patient.

(2.) Sufficient technical training to produce and finish radiograms showing all details clearly, which will compare favorably with any that can be produced.

(3.) A thorough knowledge of embryonic development, histology, pathology, bacteriology, and anatomy.

(4.) A knowledge of dentistry so as properly to interpret the findings as disclosed by the radiogram when considered with the clinical findings.

The radiogram therefore is valuable in oral diagnosis when interpreted by one thoroughly schooled in dentistry and one who understands what it really shows, and who knows its defects and limitations. It is entirely wrong for physicians, technicians and others who have no knowledge of dentistry to undertake to interpret these views for either the patient or for dentists, as there may be a misinterpretation of what is shown, or a faulty diagnosis.

The radiogram does not show infection, but it does show the results of infection, injury and pathological changes. Many people have great imaginations and profess to see conditions in radiograms which are not apparent to others. Since only certain conditions are disclosed in the radiogram, it is well not to speak of the results of other clinical findings as being shown in the radiogram, such as "infection shown at the apex," etc.

There are six structures of immediate importance in radiograms of the teeth, namely:

(1.) Tooth structure (cavities, impactions, etc.).
(2.) Pulp chamber (pulp stone, condition of chamber, etc.).
(3.) Root-canal (fillings, instruments, etc.).
(4.) Periodontal membrane and periapical space.
(5.) Stratum durum.
(6.) Alveolus.

Other structures of importance to the dentist are:

(1.) Sinuses (maxillary, frontal, ethmoid, and mastoid).
(2.) Soft tissues (stones and foreign bodies).
(3.) Joints.

Successful radiographic technology demands that these structures be clearly defined upon the finished radiogram without undue distortion. The radiogram will show pathological changes in the hard tissue, but I do not consider the radiogram capable of showing pathological changes in the soft tissue, and especially the periodontal membrane, notwithstanding the assurance of some operators that they can detect these early changes through the use of the radiogram. There is no difference in appearance as shown by the radiogram of pulp tissue in vital, devitalized or purulent pulps. There is no difference in appearance of the periodontal membrane in the normal state and in the state of congestion or inflammation. When, however, these conditions of the soft tissue have progressed to the extent of

involvement of the surrounding hard tissues, then, and then only, is the appearance of these tissues changed as shown by the radiogram.

The periodontal membrane does not show upon the radiogram. The space occupied by the periodontal membrane, however, is shown. When through infection or otherwise there is absorption of the surrounding tissue, there will be a change in the continuity of the space occupied by the membrane or widening of the space. This is a valuable diagnostic point, although not conclusive in itself, as angulation may produce deceptive results.

Not all cavities are shown by the radiogram, as a cavity on the lingual or buccal surface may not show.

Apical pathology shows upon the radiogram only when there has been absorption of the alveolus.

Periodontal involvement shows upon the radiograph only when there has been absorption of the alveolus.

Pathological bone changes as shown by the radiogram may be classified as:

(*a*) Periodontal alveoclasia; (*b*) Periapical alveolitis; (*c*) Rarefying ostitis: diffuse type; circumscribed type (granuloma); (*d*) Cyst: radicular; dentigerous or follicular; multiocular; and dermoid; (*e*) Necrosis and sequestrum; (*f*) Osteitis serrata (edentulous sharp process); (*g*) Osteosclerosis (condensing osteitis); (*h*) Osteogenesis.

The radiogram does not show the contents of radiolucent areas (dark areas on the negative). This area may be sterile, infected, or in process of repair or osteogenesis. The radiogram does not show whether these areas contain fluid, pus, granulation tissue, blood, etc., excepting indirectly through association by our knowledge of these conditions occurring with the type of bone destruction shown upon the radiogram.

Nomenclature.—The following definitions may be of value to the reader:

Radiogram Röntgenogram Skiagram	synonyms for	Shadow view of area exposed to X-rays
Radiograph Röntgenograph Skiagraph	synonyms of verb	to make a radiogram to make a röntgenogram to make a skiagram
X-ray Röntgen Ray	synonyms for	Actinic ray discovered by Röntgen in 1895

Radiography Röntgenography Skiagraphy	defined as	The art of producing a radiogram The art of producing a röntgenogram The art of producing a skiagram
Röntgentherapy Radiotherapy	" "	X-ray or Röntgen-ray treatment
Stereoscopic Radiography " Röntgenography	" "	Method of producing a radiogram for each eye, the position of tube being changed 2½ inches after first exposure in order to gain perspective
Stereoradiograms Stereoröntgenograms Stereograms	" "	Two views having perspective as produced by stereoscopic radiography
Fast film (improperly called negative)		One that has very sensitive emulsion and takes short exposure
Slow film (improperly called positive)		One that has less emulsion and takes longer exposure
Positive print		First copy made from original radiogram and shows degrees of density reversed.
Negative print		Second copy which brings densities back as shown in original radiogram
Radiability		The property to transmit the X-ray
Radioparent Radioparency		Offering no barrier to X-ray
Radiolucent Radiolucency		Offering slight resistance to X-ray
Radiopaque Radiopacity		Impervious to X-ray

Radiability of tissue and other substances:

Radiolucent	Skin mucous membrane pus periodontal membrane wood flesh rubber (not vulcanite) cotton paraffin	Casts black shadow
Radiopaque	Bone dentin lamina dura enamel pulp stone	Casts light shadow
	Metal fillings shell crowns bridge work root canal fillings (except paraffin) steel, lead, gold, etc.	Casts very light shadow

PRACTICAL USES OF THE RADIOGRAPH IN DENTISTRY

(1.) As an aid in determining whether or not the teeth are responsible for oral sepsis and causing general systemic disturbances.

(2.) As an aid in locating the cause of local and reflex pain.

(3.) Apical alveolar absorption—extent and nature of area; to determine which root affected in multi-rooted teeth; number of teeth involved; differentiation between apical and periodontal involvement.

(4.) Periodontal alveolar absorption—extent of area, number of teeth involved, etc.

(5.) To determine if there is apical root absorption, or periodontal root absorption.

(6.) To determine if there is apical excementosis.

(7.) Deciduous teeth—to determine if present, roots fully formed, roots absorbed, whether deciduous or permanent, when to extract, position, etc.

(8.) Permanent teeth—to determine if present, roots fully formed, position, etc.

(9.) Practice of orthodontia.

(10.) Supernumerary teeth.

(11.) Impacted teeth.

Fig. 8.

Needle in soft tissues of lower jaw (to the right of illustration). Note the admirable contact of the four remaining teeth on this side.

Fig 9

Bullet in upper maxillary bone ; lateral view (same case as Fig. 10).

Fig. 10.

Bullet in upper maxillary bone ; antero-posterior view (same case as Fig. 9).

Fig. 11.

Wired fracture of the lower jaw, showing loss of bone structure.

Fig. 12.

Cyst of lower jaw.

Fig. 13.

Round-celled sarcoma of the upper jaw.

Fig. 14.

Osteon a of lower jaw.

(12.) Localization—impacted teeth, foreign bodies (Figs. 8, 9, and 10), etc.

(13.) Root-canal—number of canals, possibility of getting into canal, obstruction, perforation, condition of canal filling, to prove root-canal filling, etc.

(14.) Pulp stones and secondary dentine.

(15.) Course of fistulous tract.

(16.) Field of operation before and after apiectomy.

(17.) Exodontia; root formation; lamina dura, tooth structure, hidden roots, unerupted and impacted teeth, checking up after extractions; metal in sockets, bone in sockets, sharp process, etc.

(18.) Fracture of root or fracture of bone. (Fig. 11.)

(19.) To observe teeth as possible abutments—formation, position, condition of root, length of roots, etc.

(20.) Replanted teeth.

(21.) Osteosclerosis.

(22.) Calculi in salivary ducts.

(23.) Calculus upon roots of teeth.

(24.) Cysts and tumors. (Figs 12, 13, and 14.)

(25.) Necrosis.

(26.) Fusion of roots and anomalous conditions.

(27.) Antral empyema—proximity of areas of absorption around teeth to antrum, obstruction of sinus, roots and foreign bodies, size and shape and location of sinus with reference to the teeth.

(28.) Ankylosis.

(29.) Where patient cannot open mouth for ocular examination.

(30.) Research work.

(31.) Dental caries.

(32.) As a record of work done.

(33.) As a protection against suits, etc.

Misinterpretation of Radiographs.—The following are some of the common causes of misinterpretation of dental radiograms:

(1.) Mistaking normal anatomical structures for pathological changes: (*a*) mental foramen; (*b*) inferior dental canal; (*c*) normal bone cells for apical areas of alveolar absorption; (*d*) nasal sinus; (*e*) maxillary sinus; and (*f*) anterior palatine canals.

(2.) Improper angulation, causing distortion, or producing deceiving results.

(3.) Insufficient number of views at proper angles to prevent overlooking of pathological areas.

(4.) Mistaking sterile areas for infected areas.

(5.) To attempt to determine exact distance or measurement from radiogram.

Dangers from the Use of X-rays and X-ray Burns.—Many people are extremely afraid of the X-ray and are apprehensive as to its local and general effects. There is no question but what the X-ray is dangerous and that continued exposure will produce untoward results. There would seem, however, to be but little danger in the careful use of the X-ray for dental purposes. If the operator will but protect himself there appears to be no danger whatever to him. It is needless to say that an operator should never hold films for the patient or directly expose himself in any way or have his assistant do so. A continued practice of this kind would produce an X-ray burn.

Many types of apparatus at the present time have the tube fully enclosed in lead glass or with a lead shield and for low-power apparatus of 10 milliampere capacity this would seem sufficient where the operator stands back from the tube. When 25 milliampere current or more is used, it is well to take double precautions and stand behind a lead screen or door. The further the operator stands from the tube the better.

There is more danger to the patient, who is exposed to the direct rays. An aluminum filter should always be used, and the number of exposures kept within reasonable limits. Patients should be questioned regarding previous exposures. There should be no hesitancy in exposing at one sitting for 15 to 20 small films. If others are necessary, it is advisable to wait 2 or 3 days before further exposure. I know of at least one case of pronounced dermatitis produced by exposures for small dental radiograms, but this occurred in a case where the operator was not familiar with proper angulation, and the views were retaken a number of times without an intervening rest period. I, personally, caused one case of transient alopecia, or loss of the hair, by an exposure of 25 milliamperes, 4½-inch back-up spark, distance of 15 inches from focal spot of tube to plate, using an illuminum filter, and exposing for 15 seconds for one exposure only. I considered this burning as due to extreme susceptibility, as previously I had not hesitated to use one minute exposure at

18-inch distance with above conditions, and had not had this occur. It is now my practice to use a double screen intensifier with tube distance of 18 inches with an exposure of 3 seconds or less. While under these conditions it may be considered safe to take two or three views, I take only one postero-anterior view at one sitting.

There should be no hesitancy in exposing three or four lateral views of the head, as the exposure here is the same as for small dental film held within the mouth, and the current does not pass directly through the hair.

I want to call particular attention to the danger attached to the long exposure necessary to expose No. 2 Eastman dental film held between the teeth and taking vertical angle as in the Simpson method of localization.

Injuries attributable to X-ray burns are acute dermatitis, chronic dermatitis, cancer, sterility, leukæmia, abortion, insanity, lassitude and other systemic disturbances.

Acute X-ray Dermatitis.—Acute X-ray dermatitis resembles an ordinary sunburn. It is usually accompanied by a sensation of tingling, itching or burning. It may occur immediately within a few hours or after a period of one or two months or more. It usually appears within one week. The itching and redness may become more severe, swelling occurring, and the skin present a dry, harsh, glossy appearance. In mild cases, the inflammatory symptoms may subside within a few days and the tissues recover. In the more severe cases the degeneration proceeds with formation of blisters, exudate and involvement of the deeper tissues.

Chronic Dermatitis.—After a number of over-exposures or more than one appearance of acute dermatitis, the dermatitis becomes chronic, accompanied by pigmentation or tanning of the skin, freckles, wrinkled, dry, harsh skin, and loss of hair. Small, hard, scabby growths now appear, and later degenerate into ulcers, which may later become cancerous growths. The hands are the most usual site of chronic dermatitis, although the face and chest are likely to become affected.

Cancer.—Acute or chronic dermatitis may degenerate into a cancerous condition with deep tissue involvement. The pain is usually very extreme and severe.

Alopecia.—Loss of hair as a result of X-ray burn is not uncom-

mon, and occurs in most stages of dermatitis. It is most usually seen upon the head as a result of exposures for radiographs of the sinuses or for any view which requires that the rays pass through the hair. If the burn is not too severe, as to cause the destruction of the hair follicles, the hair returns within five or six weeks.

Stereoscopic Radiography.—The ordinary single radiogram is a flat negative and is often lacking in detail and depth, so as to render an interpretation of the labio-lingual or bucco-lingual position of objects difficult and often very unsatisfactory. For interpretation a stereoradiogram has every advantage over a single radiograph, but the disadvantage is the long technic of producing it. For views of certain conditions in some positions in the mouth the technic is not extremely complicated. However, the technic for producing stereograms is not as simple as that required for plain radiograms, and the time required is far greater.

While in most instances entirely satisfactory results can be obtained without stereograms, there are times when they are needed badly and the extra time spent in producing them is well spent, and the result will be far superior because of more certain interpretation.

I have found the most practical uses of the stereoradiogram in dentistry to be:

(*a*) More clearly defining the depth and extension of areas of osteitis and necrosis.

(*b*) Detail in all cases is more clear.

(*c*) Localization of impacted teeth, unerupted teeth, broken instruments, foreign bodies, tooth germs, etc.

To produce stereoradiograms it is necessary to take two ordinary radiograms upon separate films from points 2½ inches apart, with provision for exchanging the film or plate after first exposure without changing its relative position. This must be accomplished by having film or plate fixed in a given position so that it cannot slip or move, by having the patient remain in one fixed position during the process, and by exchanging the film or plate after first exposure without changing its relative position. The film or plate taken from the right-hand angle is marked "right" and the one taken from the left-hand angle is marked "left."

Stereoradiographic small films are best studied by the use of a small parlor stereoscope by mounting the views upon ordinary two-window film mount, with windows 2½ inches apart (the films being 2½ inches apart). Large plates are best studied by the employment of a properly lighted Wheatstone or similar type of table stereoscope.

In mounting the films or plates for examination, there is a difference in the result shown by reversing the films or plates. This is a most wonderful feature about this work. If the left-eye picture is placed on the left, and right picture on the right of the stereoscope, upon looking at them it will be found that we are looking through the jaw from the same direction that the rays were thrown. With the views so placed, we appear to look down through the buccal plate, through the alveolar process and so on. Everything appears just in these relative positions. These views present a buccal aspect of the case.

When we reverse the views, placing the right-eye view on the left and the left-eye view on the right, a most wonderful transformation has taken place, for now we are looking through the jaw from a position within the mouth and now they present an actual lingual aspect. Strangest of all is the fact that viewing the radiograms in this direction is the most satisfactory of the two, so that the views are best reversed for reading.

Localization.—It would be difficult to over-estimate the importance of the determination of the exact location in the tissues and maxillary bones of impacted and unerupted teeth, foreign bodies, broken instruments, etc. This is extremely necessary in the practice of oral surgery, exodonia and orthodontia. Before attempting an operation for removal of teeth, foreign bodies, instruments, etc., or moving teeth, their exact location should be definitedly determined, which will greatly simplify the operation.

Palpation is useful in locating bodies in the soft tissues, such as stones, etc., and is also useful when the body causes a bulging of the outer or inner plates of a maxillary bone.

Probing is found useful in following fistula. Transillumination is also an aid, and especially in locating objects within the maxillary sinus. Radiographic examination, however, proves to be the most

valuable diagnostic aid in localization. Radiographic information as to location may be obtained in the following manner:

(1.) Single radiograms.
(2.) Two or more views taken from different positions.
(3.) Stereoscopic radiograms.
(4.) Two or more different kinds of views.
(5.) Use of metal wires or probes.
(6.) Fluoroscopy.

1. A single radiogram, while lacking perspective, proves the most easy and useful method of determining position of unerupted and impacted teeth. The single radiogram should be taken correctly so as to show the least possible distortion.

In lateral intra-oral views there should be no overlapping of contact points of approximate teeth. In the location of third molars the contact point between first and second molars is the key to the correct angle, as this should be normal with no overlap. If a lower third molar appears to overlap the second molar in a view of this kind it lies to the buccal side, as our knowledge of anatomy proves it could not lie to the lingual because of thin inner plate. Upper molar may lie to lingual or labial side, but palpation will usually locate tooth if overlapping is shown in radiogram.

As the impacted tooth inclines more toward the lingual, the smaller the root shown and the larger the occlusal surface of crown shown. In complete lingual displacement, where occlusal surface of crown faces the lingual there will be no root formation seen when radiogram is taken in ordinary manner. The root, however, can be shown by taking setting angle of tube in position for an upper molar exposure in order to show root of lower molar; and *vice versa,* for showing root of upper molar. This also applies to bicuspids.

The Simpson method of placing No. 2-A film between teeth and taking vertical angle has some advantages and will show location when there is definite buccal or lingual position. The disadvantage is long exposure and danger of alopecia. In the localization of impacted cuspid teeth, one view usually proves sufficient. Most impacted cuspid teeth lie lingually to the other teeth. When the cuspid lies buccally to the other teeth it may be located by palpation, owing to the thin outer plate and tissue over roots, etc. It is true, therefore,

when a cuspid is shown to overlap other teeth, and cannot be located buccally by palpation, it lies to the lingual.

There are some few cases where this method does not give the desired information, such as an edentulous case where there are no other teeth to gauge position and in cases where an unerupted or impacted cuspid does not overlap other teeth but is erupting in normal mesio-distal relationship.

2. The stereoscopic method has been fully described under stereoscopic radiography. Stereoradiograms are always useful, but not always necessary. In all cases detail is more clear, and in many cases perspective is shown. Perspective is not shown in all cases, as where the object or impaction lies extremely close to the other teeth, the distance between them is not sufficient for accurate perspective. The farther the distance the more the perspective. Large stereographic plates will always show upon which side the impacted tooth lies, but will not always show its relationship bucco-lingually to approximating teeth.

Stereoradiography is more useful in localization of broken instruments and objects in the soft tissues, and in bone not lying immediately approximating the teeth. Stereoradiography is, therefore, limited in its usefulness in localization.

3. Two or more views taken from different positions may be used to best advantage in the case of impacted cuspid teeth not overlapping other teeth, and in instruments and objects closely approximating the teeth. This method, described by Raper, Ivy, and others, is based upon the following principle: In observing two objects in direct line, the more distant object will appear to the right when the observer moves to the right, and the nearer object will appear to the right when the observer moves to the left, the more distant object moving in the direction taken by observer. Therefore, applying this principle to radiography, in a lingual impaction where the object is more distant than other teeth from tube the impaction will appear to move to the right in a succession of films each taken a little further to the right. If the impaction lies to the labial of the other teeth, it will appear to move to the left in a succession of films each taken a little further to the right.

4. Two or more different kinds of views are often desirable

to take lateral head view and postero-antero or antero-posteros to locate teeth or some object.

5. *Use of Wires or Probes.*—It is often found difficult to locate the exact position of portions of roots in edentulous cases where they have been shown to exist by large films or plates. This may be accomplished by sticking sharp piece of gold, probe or metal into tissue in position where root is suspected and radiogram will show proximity of metal to root. It may be necessary to take two or more views until metal appears to touch object. Often measurements from other landmarks on radiograms prove useful.

In locating teeth and objects far removed from the other teeth, valuable information may often be obtained by crossing two wires over spot where body is suspected, and a lateral plate taken. If the crossing of the wires is shown by radiogram to be exactly over tooth or body, the approximate lateral position may be determined.

Conclusion.—It will be found that there is no one method of localization which will give good results in every case. Each of the various methods is useful in certain cases. The best results are only to be obtained from a thorough knowledge of all the different methods and the use of those best suited to the individual case.

Use of Electric Pulp Tester in Dental Diagnosis.—The fundamental requirement of diagnosis of tooth pathology is to distinguish vital from non-vital teeth. The electric pulp tester should supplant, as near as possible, the old method of drilling into teeth to determine vitality. The radiograph and other means are often confusing and lacking in positive information, so that the pulp tester is not only a valuable supplement but almost indispensable. The pulp tester is often unreliable when used without radiographs. The most satisfactory procedure is to first obtain radiographs of the entire mouth where possible and to supplement this with the use of the pulp tester as a check for vitality in connection with the radiographs. Where circumstances do not permit of full-mouth radiographs or where the purpose of examination is to determine cause of local disturbance it is well to both precede and supplement the radiographic examination with electric test.

The method of using a pulp tester to ascertain the vitality of the pulp of a tooth, is based upon the reaction observed when a weak electrical current is passed through the tooth, which conveys to us

the state of sensory innervation of the tooth. The action of the current upon a sound, vital tooth produces a definite tingling sensation. The strength of current required to produce this sensation is different for different teeth and for different patients.

In the diagnosis of diseases of the dental pulp, it is necessary to take into consideration the following conditions: (*a*) Normal; (*b*) hyperæmia; (*c*) acute, active simple inflammation; (*d*) acute, active purulent inflammation; (*e*) death of pulp.

PRACTICAL USES OF PULP TESTER

(1.) Where radiograph is not available and where it is used in connection with transillumination.

(2.) Checking and supplementing radiographic and transilluminating and clinical evidence to make diagnosis more certain.

(3.) To determine vitality or non-vitality where radiograph does not disclose definite bone absorption.

(4.) There is no one method infallible, and the pulp tester may disclose pathologic conditions overlooked in other examinations.

(5.) As a protection against misinterpretation of radiographs of anatomical structures for diseased areas, such as mental foramen, incisive foramen, anterior palatine foramen, maxillary sinus, nasal sinus, inferior dental canal, etc.

(6.) To differentiate in cases where radiographs disclose radiolucent areas involving apices of vital teeth due to angulation or overlapping of a buccal or lingual area of bone absorption.

(7.) To differentiate between a very small periapical area of bone absorption and an unusually large normal periapical bone space or bone cell.

(8.) To differentiate between periodontal and periapical involvement.

(9.) In the diagnosis of pathology of deciduous teeth radiograph is very deceptive and pulp tester of great value.

(10.) To differentiate between partially formed root and alveolar absorption.

Apparatus.—It is necessary to have an electric instrument equipped with a finely graduating rheostat or current control, such as a dental switchboard, ionization board or a small portable transformer. There are also portable outfits whose source of energy is

through dry-cell batteries. It is necessary to have a pair of insulated electric cords which are to be attached to the source of supply (pulp-testing apparatus), and to the other ends are attached the electrodes. One electrode should be a metal handle to be placed in the patient's hand, and the other electrode should have a pin-head terminus for applying to the tooth to be tested. It is well to have an electrode to apply to the teeth with a replaceable brass pin, so that the pin may be removed, and sterilized easily, or a new one put in place.

There are two classes of appliances, the faradic current and the galvanic current.

The type of apparatus making use of the faradic current has not proved so popular for testing pulps of teeth. In this type the faradic current is obtained from the secondary winding of an induction coil, the primary winding of which is a mechanical interrupter or vibrator in its circuit. The source of current is generally one or two dry cells connected to the primary winding. When the street current is used a resistance lamp is in series to reduce the 110 volts direct current to the voltage equivalent to that obtained from the dry cells. In this type of apparatus it is not possible to measure or accurately to gauge the strength of current used in a given case, because of the variation caused by the adjustment of the mechanical interrupter or vibrator, or, when a battery outfit is used, because of the usual deterioration of the dry cell with use. Furthermore, the current produced by the ordinary commercial faradic coil is not sufficiently weak for pulp testing, nor can the current be regulated with sufficiently fine gradations.

The type of apparatus that has proved universally satisfactory is the galvanic current type. The galvanic current is nothing else than, and is another term for, direct current.

Ordinary street current of 110 or 220 volts, either alternating or direct, may be used with some forms of apparatus on the market, thereby eliminating all dry cells. Such an apparatus is made with the understanding that the maximum electric current required for pulp testing is about 50 volts, and there is a resistance unit built into the pulp tester to cut the street current voltage from whatever it is to 50 volts. In order to make it possible for the current strength to vary from zero to 50 volts, in steps of a small fraction of one volt, the entire 50 voltage is run across a fine rheostat.

I have found this apparatus particularly useful, as it can be used in the office and for examinations of patients confined to their homes where the radiograph is not available and where it is necessary to make a decision as to which teeth are the probable cause of systemic disturbances. It can be used on any current, and is portable and easily carried.

Directions for use of pulp tester: Connect the pulp tester to a 110-volt lamp socket, and plug in the connecting cord to socket marked "pulp test." The "hand electrode" is connected to one of the cord tips, and the other cord tip is connected to the insulated holder of the "tooth electrode." To apply current to the electrodes, pull switch out. The little pilot lamp will light up slightly when the line current passes through the pulp tester. With the current controller at zero, you obtain the minimum of current strength.

Technic of Applying Test.—Metal electrode is placed in patient's hand. The dental electrode is applied by the operator to some apparently normal tooth in the patient's mouth. The least amount of current necessary to produce a slight tingling sensation in testing a tooth, without giving pain or shock, is known as the *irritation point,* and the position of the rheostat on the current control should be noted at this time and recorded. The electrode should be applied to the tooth with the minimum amount of current available and gradually increased until the irritation point is reached. The irritation point should be determined by testing either upper or lower anterior teeth, and preferably upper teeth. Teeth of one side of mouth may be checked against same teeth on opposite side of mouth. Where possible apply electrode to lingual surface of incisors and cuspids and occlusal surfaces of bicuspids and molars.

It is preferable to have the tooth dry and free of saliva so that there will be no short circuit—this may be done with cotton. If there are metal fillings in contact with adjoining teeth, they should be insulated by piece of rubber dam, as current may be conveyed to adjoining tooth and a positive reaction shown. The normal irritation point is not the same for each tooth in the same patient's mouth, as this depends upon the thickness of enamel, erosion, cavities, attrition, etc. The more dense the material between the point of electrode and the dental pulp, the more current is required to give response.

All patients react differently to this test, depending upon their nervous temperament.

While the irritation point as shown by the rheostat may be recorded, as well as the postion of rheostat on positive reading and position of rheostat on negative reading, this is not always practicable, and the above method has served my purpose just as well and requires less time.

DIAGNOSTIC STAGES OF RESPONSE TO TEST

(1.) Normal response: The normal tooth responds to the current at the irritation point.

(2.) Sub-normal response (irritated pulp and hyperæmia): Inflammation (*a*) the irritated pulp responds to the current at the irritation point or slightly below it, taking less current to give response; (*b*) the inflamed pulp or hyperæmic pulp responds to the current below the irritation point, taking less current to produce response. The more severe the inflammation, the less current required to produce response. Where there is a response to less than the normal dosage, there will undoubtedly be an early pathological involvement of the pulp.

(3.) Supra-normal (acute purulent involvment): The inflamed pulp with suppuration responds to the current above the irritation point, taking more current to give response. A tooth known to be devitalized and responding positive to the test shows the presence of putrescent material in canal and at apex, more than the usual number of canals, or faulty technic. A tooth requiring an excess of current is not normal.

(4.) No response (dead pulp): When the pulp does not give response even when the full amount of current is used, it is positively devitalized.

Vital Factors to be Remembered.—(1.) The pulp tester should not be used to supplant the radiograph and transillumination, but to supplement them.

(2.) Tooth to be tested must be fairly dry.

(3.) Close contact with other vital teeth should be considered and especially where there is metal.

(4.) Rubber dam or non-conductor should be placed between teeth where necessary.

(5.) Shock is produced when electrode is applied to sensitive dentine.

(6.) Do not place electrode too near gum tissue, as there will be a deflection of the current.

(7.) Do not touch tongue or soft tissue when using high buttons of rheostat.

(8.) Patients sometimes deceive operator in expressing the subjective symptoms of the response of the current.

(9.) In testing the teeth the operator should watch for objective symptoms to the response of the teeth to the current.

(10.) Patients will sometimes state they feel current when they feel only contact of electrode.

(11.) Some patients are very susceptible to suggestion.

(12.) In multi-rooted teeth remember that one nerve may be dead and another vital.

(13.) Teeth with one root sometimes have more than one nerve canal, and one nerve may be vital and another dead.

(14.) Contact with all metal fillings or crowns should be avoided, as the reaction will be painful. Crowns have to be removed in order to test underlying tooth.

(15.) Teeth with very large fillings which cover most of the crown give an unreliable response, as the current may be short-circuited to the periodontal membrane or to the pulp chamber of a vital tooth adjoining.

(16.) Patient must not be in direct contact with metallic parts of dental chair.

(5.) *Bacteriological and Clinical Examinations.*—Macroscopic and microscopic bacteriological examinations prove valuable diagnostic aids in determining the presence of infection and the nature of the organism. The nature of the organism is often the deciding factor of the diagnosis, as in the case of periodontoclasia (pyorrhœa) and acute or chronic ulcero-membranous gingivitis, where the presence of the fusiform bacillus and Vincent's spirillum in large numbers conclusively shows the condition to be ulcero-membranous gingivitis.

This method is also used in determining the sterility of canals in root-canal work.

Leucocyte counts of mouth conditions furnish information of

value only in exceptional cases, and the leucocyte reaction is not essentially different from that due to infection elsewhere in the body.

(6.) *Pathological Tissue Examination.*—To determine the nature of any pathological growth, a section of same may be cut off and prepared for microscopic examination. The positive diagnosis is often based upon the structural characteristics of this specimen.

(7.) *Biological and Chemical Tests.*—The most important of these is the Wassermann test; it should always be made when syphilis is suspected.

(8.) *Differential Diagnosis.*—Differential diagnosis is accomplished by comparison of all of the symptoms usually shown by one disease with the symptoms usually shown by other diseases and is a process of exclusion. An illustration of differential diagnosis may be seen in a comparison of the symptoms of pulp disturbances and those of the periodontal membrane.

(9.) *Treatment Recommended.*—After a study of all the facts elicited, the best treatment for the individual case is recommended, and recorded for future reference.

ORAL PROPHYLAXIS

It should always be remembered that the mouth is the gateway through which all nourishment passes into the body, and through which many germs gain access to the system by means of the air used in breathing. That the oral cavity should be kept pure and clean in order that the health of the individual might not become impaired, would seem to be axiomatic. But the rule is not applied for one reason or the other in the great majority of instances, and the health of the community at large is gradually being undermined by a neglect of the teeth that is absolutely unpardonable from every point of view.

It is well at the start for the physician to be familiar with the meaning and use by dentists of the words (1) abrasion; (2) caries; and (3) erosion, and what may happen when these conditions are not properly attended to in the teeth.

ABRASION

Definition.—Abrasion is the mechanical wearing away of tooth structure or substance. It is more often found upon the occlusal surface of permanent teeth, although it often affects the deciduous

teeth. Abrasion of the labial surface is quite common, while abrasion of the lingual and approximal surfaces is less often seen.

Abraded surfaces usually present a smooth, highly polished appearance which may be flat or concave. In extreme cases the marginal ridges and cusps may be very sharp or rough. The surface is often stained through the use of tobacco, drugs, fillings, etc. The smooth surface is often altered by subsequent caries.

Wearing away of tooth structure as a result of attrition is to be expected in every mouth and is accepted as normal to all teeth, increasing in amount with use and age. Abrasion of this kind is not so pronounced as in the case of abuse or neglect of the teeth.

(*a*) Some teeth are very susceptible to abrasion because of malocclusion or imperfect tooth structure. In the case of malocclusion there will be undue stress and wear upon one or more of the teeth in the arch and early abrasion. Teeth whose structure is imperfect, as well as teeth having cavities and erosion, are easily affected by abrasion. Coarse and gritty food hastens abrasion.

(*b*) Extractions cause abrasion in many cases by permitting opposing tooth in opposite jaw to occlude improperly, or by throwing more stress upon the remaining teeth, as in the case where posterior teeth are extracted and the stress is then greater upon the anterior teeth.

(*c*) Occlusal wear is very common with men who chew tobacco or smoke pipes, gritting of teeth by nervous people, biting of thread, or holding of tacks, nails, etc., between the teeth.

(*d*) Labial and approximal abrasions are often attributed to the use of too gritty pastes and powders, or too vigorous use of tooth brushes, or brushes having very coarse bristles.

(*e*) Lingual occlusion is often caused by a marked overbite, allowing the lower teeth to occlude with too much stress upon the lingual surface of upper teeth. Irritation from prosthetic appliances, etc., is often the cause of abrasion upon the lingual as well as upon other surfaces.

(*f*) Impacted third molars and other teeth that are not fully erupted often cause interproximal abrasion by abnormal contact.

(*g*) Clasps for bridges and prosthetic work usually cause extensive abrasion.

The external effects of abrasion are those caused by formation

of sharp edges or ridges which may produce pathological changes of tissues of the mouth coming into contact with them; or local pain from irritation of these projections; or difficulty in restoring lost teeth because of the close bite produced by abrasion, and extreme cases may alter the facial appearance.

The internal effects of abrasion upon the pulp is a progressive irritation and consequent progressive changes through the recession of pulp chamber and formation of secondary dentin and formation of pulp nodules or calcification, or there may be apical irritation, and all the serious train of symptoms found in such conditions. In some cases where the pulp does not properly protect itself there may follow inflammation, hyperæmia, and degenerative changes, resulting in death of the pulp, formation of abscess, etc.

CARIES

Caries, according to Black, is "a chemical dissolution of the calcium salts of the tooth by lactic acid, followed by the decomposition of the organic matrix, or gelatinous body, which, in the dentin, is left after the solution of the calcium salts." The medical use of the word "caries" implies a piecemeal disintegration of bone, as distinguished from necrosis, in which the bone dies *en masse* or spontaneously. Decay is the term often used as synonomous to dental caries, and its use in dentistry applies to the disintegration and decomposition of the tooth structure. Both vital and non-vital teeth are subject to decay. The usual form of caries is that of the enamel and dentin, although caries may extend to the cementum from the dentin or it may start in the cementum when the gum has receded, exposing the cementum to the fluids of the mouth. Caries may affect any portion of the tooth, but the usual position is in pits, fissures, opproximal contact and areas of imperfection.

Black states that decay is primarily due to the growth of bacteria (streptococcus, staphylococcus, and other mouth organisms) in contact with the outer surface of the enamel, with the consequent production of lactic acid, which dissolves the cementing substance of the enamel rods and allows the invasion of the bacteria into the dentin. Unclean surfaces of the teeth are particularly susceptible to decay and therefore closely associated with decay.

The predisposing causes of decay may include malocclusion,

defective dental work, mechanical injury, erosion, abrasion, tooth structure defects, systemic disorders, etc.

All normal dentin is sensitive to external influence, and the degree of sensitivity differs very much in different individuals. By exposure to external agencies through erosion, injury, abrasion, structural defects, etc., the dentin may become pathologically sensitive, or hypersensitive, to such an extent as to be extremely painful to instrumentation or to cause painful symptoms or reflex pain in adjacent parts.

Caries of the teeth usually progresses without pain until the tooth becomes hypersensitive on account of irritation of the pulp tissue, although there may be a slight degree of uneasiness. Sensation in dentin is derived from the pulp through the dentinal fibrils, as dentin has no nerves. Normal dentin and decay involving the dentin, without pulp inflammation, is not sensitive or painful excepting to special irritation, such as mechanical, electric, acids, sweets and salt. This sensitiveness varies greatly in different persons and in different carious teeth. Sensitiveness of dentin is greatest along the dento-enamel junction, where the fibrils are much branched, and diminishes perceptibly in the deeper parts.

Response to heat and cold denotes an involvement of the dental pulp, and is an entirely distinct condition from sensitive dentin. There may be normal thermal sensitiveness, or abnormal thermal sensitiveness known as thermal hypersensitiveness. Hypersensitive dentin may endure for a long period without thermal hypersensitiveness, or vice versa, or the two may exist together. Thermal hypersensitiveness, without hypersensitive dentin, denotes hyperæmia of pulp. Hypersensitive dentin, without thermal hypersensitiveness, denotes only irritation of pulp through dentinal fibrils. Both of these conditions are usually closely associated. The sudden disappearance of either thermal sensitiveness or hypersensitiveness denotes death of the pulp.

Discoloration or pigmentation of tooth structure as a result of caries varies from light yellow to dark brown, reddish brown and black. The slower the progress of decay the darker the discoloration. The outside of the carious dentin is usually the darkest. Discoloration is no doubt caused by extraneous substances.

Diagnosis.—In the diagnosis of dental caries both objective and subjective symptoms are of importance.

Objective Symptoms.—A systematic examination should be made of each tooth and cavities noted upon a suitable diagram or diagnostic chart. Every portion of each tooth should be carefully examined and in regular order.

Often the signs of existence of cavities are apparent upon visual examination or reflected in a mouth mirror. The entire tooth surface should be explored with a sharp instrument, and the necks of the teeth should also be examined to determine softness of tooth structure. The margins of all fillings should be explored to test marginal walls and to locate any excess or deficiency of filling material.

The use of a strong electric mouth lamp will often disclose hidden cavities, as there will be a reflection as of an opaque spot.

The radiograph is very valuable, and often discloses cavities not found by other means of diagnosis, and which have been overlooked.

Subjective Symptoms.—Pain may be of varying degrees of intensity, and as expressed by the patient may be deceiving as to location of tooth.

Complaints of patients of pain from hot, cold, salt, sweet or acid in contact with the teeth often leads to discovery of cavities. There may also be pain without application of these external stimuli, caused by hyperæmia of pulp. By the use of hot or cold water in an ordinary hypodermic syringe applied over the surfaces of the teeth or to some suspicious area, cavities may be definitely located.

Pain produced in mastication may lead to discovery of cavity, as this condition denotes either congestion of pulp or pericementitis.

EROSION

Erosion of the teeth is a characteristic loss of substance of the teeth beginning in the enamel upon surfaces free from attrition by mastication, which slowly spreads inward.

Erosion starts in the enamel and may invade the dentin. It usually occurs in vital teeth, but it also occurs in devitalized teeth. The progress is usually very slow, sometimes requiring a number of years to penetrate the enamel. In some cases the progress is spontaneous. It is most commonly found upon the buccal or labial surfaces. There are some few appearances upon proximal and lingual surfaces.

The initial appearance discloses only slight loss of substance, as if a slight depression were made in the outer surface of the enamel with a stone. This may gradually spread and deepen, there being no line of demarcation between the two tissues. The area of eroded surface is always smooth and glossy. Forms: Disk-shaped, two forms; wedge shape, two forms; flat shape, irregular.

There are many views as to the cause of this condition, and it is probable that it is due to various causes. Among the possible causes may be cited: (*a*) General malnutrition and formation of systemic acidosis and acidity of the mouth; (*b*) faults in formation of tooth structure; (*c*) abrasive action of brushes, pastes, powders, etc.

The local effect of erosion is usually extreme sensitiveness, causing pain and discomfort. There may be reflex or general disturbances because of extreme sensitive and painful areas. Mastication is often slighted because of pain. The effects produced in the tissue are usually of the progressive type, such as calcification and formation of secondary dentin, etc. The progress may be more rapid and the pulp involved and the degenerative pulp changes occur.

CARE OF THE TEETH

In the proper care of children's teeth, the first teeth to erupt may best be cleansed by supplementing the mouth-rag by a very soft tooth-brush and the use of plain water; dental cream may be used later on. A careful watch should be kept for cavities in children's teeth, and little children should not be allowed to eat candy or other sweets, because of the serious effect upon the teeth. W. D. Halliburton (*Brit. Med. Jour.*, Feb. 25, 1922, p. 323) utters a special warning against allowing children to go to bed with sweets in their mouths. Normal occlusion should be maintained by early fillings where necessary, extraction of the teeth at the proper time, elimination of thumb sucking and other detrimental habits, and orthodontia assistance should be obtained when and as necessary. Mouth breathing should be recognized, and the necessary steps taken to cure it.

The teeth should be correctly and thoroughly cleansed by using the dentifrice and brushes recommended by the attending dentist which best meet the requirements of the individual case. After the use of the tooth-brush the mouth should then be washed thoroughly with a neutral or alkaline mouth wash. The principal use of tooth pastes and powders should be for their cleansing effect and very little

credence should be given to the claims of the manufacturers for their chemical action. Various reports published in the *Journal of Dental Research* show that many unjust and erroneous claims are made for various proprietary dentifrices. I prefer a combination of an alkaline dental cream and an alkaline tooth powder.

A mouth wash or gargle may be used for its cleansing and astringent effects, as well as its slight germicidal effect. I prefer an alkaline or neutral mouth wash.

Personally, to be more specific, I prefer a one per cent. solution of benzoic acid and sodium biborate in an isotonic or sodium chloride solution with water soluble menthol, or a combination of liquor antisepticus and hydrogen dioxide, or a solution made of a teaspoonful each of sodium chloride and sodium bicarbonate to a quart of water. The cleansing of the teeth should be done upon rising in the morning, after breakfast, after lunch, after dinner, and again before retiring. Waxed silk floss should be carefully passed between the teeth at least once a day. Patients should report to the dentist for examination and treatment at regular intervals of not less than every three months. This is considered the proper care of the mouth, and anything less than this does not constitute good care of the teeth. Tooth-picks, pins, matches, etc., should not be used.

Some authorities advocate that a dentifrice should be a salivary stimulant. Doctor Kells states: "I do not hesitate to affirm that a salivary stimulant is the very last ingredient a dentifrice should contain. Where is the dentist who cannot clean and polish the teeth in the upper arch of any patient when he can keep this operative field comparatively dry and free from saliva better than he can the lower teeth, which in some patients are practically flooded with saliva all the time? The slimy nature of the saliva renders it most difficult, or even impossible, to polish the teeth. Such being the case, when the dentist is trying to clean the teeth of a patient, why do not the same conditions obtain when the patient is trying to clean his teeth himself?"

Dr. G. V. Black has demonstrated that tartar is due to the overingestion of food and that it is deposited upon the necks and roots of teeth about two hours after meals. He further has shown that it is at first a soft deposit, and that it may be removed by a tooth-brush within twelve hours, but after twenty-four hours that it

becomes hard, and will then require the services of the dentist for its removal. Hence the necessity for frequent and regulars periods of cleaning the teeth.

Caries of the teeth is considered to be a chronic tooth-wasting disease caused by the disintegration of the inorganic material by acid, followed by decomposition of the organic matrix by mouth organisms. Food-particles which are left about the teeth furnish the acid necessary for this process by decomposition. Clean teeth will not decay. Sugars and starchy food are especially harmful, more so to the deciduous teeth than to the permanent ones.

Erosion of the teeth is a characteristic loss of substance of the teeth beginning in the enamel upon surfaces free from attrition by mastication, which slowly spreads inward. There are many views as to the etiology of this condition, and it is probable that it is due to various causes, among which may be cited: (*a*) General malnutrition and formation of systemic acidosis and acidity of the mouth; (*b*) faults in formation of tooth structure; (*c*) abrasive action of brushes, pastes, powders, etc.

Abrasion, as we have seen, is the mechanical wearing away of the tooth-structure or substance.

Always remember that:

(1.) Tartar or calculus should not be allowed to form upon the teeth.

(2.) Food should not be permitted to remain in contact with the teeth.

(3.) Normal contact should be maintained, and all irritation to gingivæ should be removed at the earliest possible moment.

(4.) Obtain *good* dental service, as poor work is expensive, purchased at a high price.

ILLUSTRATIVE CASES

In my next paper I shall give numerous case histories, illustrated with radiographs of normal and diseased teeth, which will show the great value of paying proper attention to the mouth in oral sepsis and in general systemic affections.

TRANSPLANTATION

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There is a great deal of discussion among the laity as well as the profession about transplantation of tissues and organs in man, and most people, even among physicians, have extremely fanciful ideas on the subject.

Asepsis and blood-vessel suture first rendered the transplantation of whole organs practicable by reëstablishing the circulation between the transplant and the host, though it had been the dream of the profession for decades. In 1880 Kocher and Lannelongue first began to transplant portions of organs in man, and they were followed by various operators who had only temporary results. For these transplants, particularly those of the more highly organized tissues, underwent autolysis and disappeared.

Doerffler in 1889 first used the continuous blood-vessel suture method now employed. Hirsch, Brian and Jaboulay were followed in 1900 by Payr, Bougle and Clermont, Tomaselli and Salvia. Other workers in blood-vessel suture were Ullman, von de Castello, Stich, Jeger, Borst and Enderlen, Lespinasse, Villard and Tavernier, Yamanöuchi, Horsley and Bernheim. Carrel perfected his blood-vessel suture by which the transplant of an entire organ such as the thyroid, kidney or spleen was effected at last with the restoration of its entire circulation.

Carrel's method of transplanting a kidney in animals consisted in removing the two kidneys *en bloc* along with a bit of the aorta and a bit of the vena cava, the ureters and a piece of the bladder; transplanting the whole into the abdominal cavity of a second animal whose aorta and vena cava had previously been divided. The segments of aorta and vena cava we sutured to the aorta and vena cava, respectively, and a piece of bladder to bladder. The urinary secretion returned; and before very long, usually the same afternoon, the

animal walks about, eats, drinks and urinates normally. Immediate results are invariably good, but after this period the results change according to whether the kidney has been replaced in the same animal or has been transplanted into another animal of the same species. Carrel found that transplantation produces lesions which are incompatible with the survival of the organ. Carrel's technic in suture is as follows: "The round, straight needles (Kirby No. 16) threaded with fine silk and sterilized in vaseline are used. The operating field is circumscribed by black japanese silk towels on which the fine threads can be easily seen. The temporary hæmostasis is secured by elastic clamps, forceps and rubber bands. The vessels are severed and the adventitia removed from ends of the vessels. The blood is not only washed out from the vessel but also from the operating field. The vessels and operating parts are then covered with warm vaseline.

"The vessels to be sutured must be approximated without much tension. They are brought together by three retaining sutures, introduced at three equidistant points of their circumference. By traction on these threads the circumference of the vessels can be transformed into a triangle. The first retaining thread is used as a continuous suture, uniting the three sides of the triangle. During the suture great care is taken to approximate accurately the cut surfaces of sections of the walls."

In my study of the histological aspect of circular suture of blood vessels, I reported my modification of Carrel's technic. The third side of the triangle with Carrel's method is made accessible for suture only by twisting the vessel for a distance of 180 degrees. By introducing the first retaining stitch on the posterior side so that the triangle formed by the three retaining stitches will have its apex downward, it was found that the vessels were twisted only for an arc of a quarter of a circle, or 90 degrees.

THYROID TRANSPLANTATION

Theodore Kocher and Payr believed that thyroid transplantation in man was much more effective and more rapid than thyroid medication, but Kocher believed that one transplantation did not suffice. Kocher also agreed with Carrel that the problem of insuring the permanency of the transplant might be solved by finding ways of decreasing the recipient's immunity and of performing the transplant

in the presence of an infection. Ten years before, Carrel and Guthrie had reported the re-implantation of the thyroid gland in a dog. The thyroid gland was extirpated and re-implanted with reversal of the circulation. Eleven days after the operation the wound was opened and the gland was found to have a good circulation; on the twenty-fifth day the same was the case; on the forty-fourth day it was easy to perceive, by the touch, the systolic expansion of the gland; the same was the case ninety-four days after the operation.

In 1906 Makkas and Stich performed experiments in autoplastic thyroid transplants. The thrombosis of the thyroid veins was the chief difficulty. When this occurred, after some time had elapsed, there were some chances of vascularization from the surrounding tissue; otherwise the transplant was lost.

Borst and Enderlen had no successes with their homoplastic experiments, and their experiments in man were total failures.

In the transplantation of the thyroid in the anastomosis of the inferior thyroid vein with the jugular vein, I found in my thyroid experiments in dogs in 1916, that the tendency to passive hyperæmia could be overcome by an end-to-end anastomosis with the inferior thyroid vein with the very much larger external jugular, instead of the termino-lateral anastomosis which had been tried previously and found wanting. In the end-to-end anastomosis, the negative pressure in the vein was taken advantage of and since I have adopted this measure, venous stasis and thrombosis in the transplant have been entirely eliminated. In twenty-five out of thirty dogs operated upon, the segments of the carotid artery remained free from thrombosis, although the gland transplanted underwent autolysis and was partly absorbed. In the absence of hemolysis and agglutination, the life of the thyroid homotransplant may be prolonged.

Lexer also believes that the cause of failure in transplantation apart from suppuration rests principally in the existence of small hematomata between the transplant and overlying tissues which prevent the nourishment of the transplant. In 1914 Von Eiselsberg reported the transplantation of portions of thyroid and parathyroid in man. At first the grafting was effective, but he admits that the function of the transplanted glands was probably only temporary.

Kawamura used Carrel's technic in his experiments on dogs which showed that the thyroid gland autoplastically transplanted could live

in good condition and functionate favorably several months after the operation.

Payr reported in 1915 seven cases of thyroid transplantations in myxœdematous patients who showed marked improvement, but most of them relapsed from three to eight years after the operation. Payr does not believe that organic cerebral defects of patients can be improved by thyroid grafting.

Bircher transplanted pieces of thyroid into the subcutaneous tissue of the occipital regions in three idiots, but after temporary improvement there was a relapse. Leichner, Stieda and Von Schaack also had negative results.

Lately Voronoff reported the thyroid transplantation from a chimpanzee into an idiot. The young man became normal intellectually and served in the World War.

The cause of the destruction of the graft is ascribed by Stich to three factors: Primary toxic action of the tissue fluid from transplanted organs; production of an antibody in the organism of the host through foreign albumen; and, finally, starvation of the transplanted tissue owing to its incapacity for assimilation of the materials necessary for its growth.

Carrel and Lexer both believe that the biological differences between donor and recipient are responsible for the checks in thyroid transplantations. My experimental work was, I believe, the first reported in the use of the Abderhalden test in transplantation. The purpose of the test was to determine the nature of the protective ferments created by the presence of the transplant. This has not, however, as yet been discovered.

Abderhalden's theory of the protective ferments of the blood is a valuable signpost to investigators in this field. Moss' grouping of the blood as in transfusion is now the most certain way of determining the tolerance of the host for the transplant.

The parathyroid gland seems to offer more resistance to absorption than the thyroid, as I demonstrated in 1916. On several dogs in which the thyroid gland had been transplanted with the accompanying parathyroids, the former showed varying degrees of degeneration and absorption while the latter remained in a perfect state of histological preservation.

BONE

Bone grafts show encouraging results as compared with thyroid transplants. Albee reported, in 1914, 253 cases of autografts of bone, a large percentage of which were successes. McWilliams in the same year showed the importance of the periosteum in transplanting the larger grafts of bone. Borth now agrees with Axhausen, Phemister and Lewis that the compact bone of the graft is absorbed and that it is replaced by bone formed by the periosteum and endosteum of the graft. Lewis holds that compact bone dies in the graft because of its physical properties which do not permit rapid enough absorption of serum to maintain the life of the bone until the vascular circulation is reëstablished. McEwen believes that if small grafts of compact bone could be used, the bone would live; but, as Lewis stated, this ideal condition is rarely, if ever, secured in bone transplantation.

Mauclaire's early report in 1915, on bone and joint grafts, cites five successful results out of a number of failures. He believes that if Küttner and Lexer's successes in the transplantation of articular fragments from the cadaver are multiplied by other operators that such transplants will give much better results than the best of resections. Lexer points out that bone grafts can now be used for defects of the skull and bones of the face and jaw. In 1908 he took rib fragments together with the periosteum from the patient for the transplant while Goebell and Dumont took fragments from the tibia. Bone grafts are also used for paralytic feet, and Albee and De Quervain transplanted bone from the tibia into defects in the spine caused by Pott's disease. This operation had been suggested by Russell Hibbs a year before. Perthes used bone transplants for flat feet. Henderson used bone grafts in fracture of the humerus with the inlay method of Albee. By this method the graft is obtained from the flat internal surface of one of the tibias, preferably by the circular motor-propelled saw. Function is often restored by this operation although primary musculo-spiral paralysis had been produced at the time of the fracture.

Albee in pseudarthrosis declares that the bone graft should always be autogenous, and it must receive early and adequate supply of blood and should therefore contain marrow. The graft must, in fact, consist of all the four bone layers, periosteum, compact bone (cortex), endosteum and marrow. The tissue layers must be brought into

apposition with the corresponding layers of the host-bone in as nearly perfect apposition as possible. For years it has been Albee's contention that the efficient bone-grower was not one individual bone layer, but the complete physiological bone unit consisting of all four elemental layers.

Haas made a number of experiments in bone transplants on dogs. An incision was made on the dorsum of the foot through the skin and subcutaneous tissues so as to expose the metatarsal or metacarpal bones with their corresponding phalanges. The selected bones were carefully removed so as to cause as little trauma as possible, and the graft was then inserted. The wounds were next closed in layers and a sterile dressing applied which was held in place by adhesive plaster. The animal was allowed to use the foot from the start. At the conclusion of the experiment, röntgenograms were taken of the feet and the bones that were transplanted to the muscles of the back. Haas found that free bone transplants, when subjected to the stimulation of normal function, undergo a slower degeneration than similar transplants without function, and that the bone transplants from old animals are more resistant to absorptive and degenerative processes than those from young animals.

Fieschi found that grafts of long bones and joints in man are practicable when similar pieces are taken from cadavers or recently amputated limbs, provided that these grafts include capsule and ligaments.

Delagénière found with osteo-periosteal grafts in long bones and the bones of the face, wrist and foot, that, clinically, radiograms showed ossification of the callus by progressive thickening of the shadow of the graft. In other cases the callus seems to begin by one or two small, bony projections from the bone ends to the graft which soon join and form a solid wall of bone, sometimes even taking the form of the bone it replaces.

Christophe's studies in dog and rabbit cause him to agree with Nageotte that sometimes a dead bone graft implanted in a living animal is useful as a bony framework for the proliferation of the osteoblasts as well as for the calcium salts it contains.

CARTILAGE

Cartilage lends itself very readily to transplantation for the correction of deformities and for substitution of bone defects. As

in bone transplantation the perichondrium when taken with the graft has the most favorable influence in maintaining the vitality of the graft. My personal clinical observation has shown that cartilage with a perichondrial covering taken from the rib and transplanted, may even show proliferation with thickening and growth of the graft—a factor which must be borne in mind in the correction of cosmetic defects such as deformities of the nose.

Lexer also used cartilage transplantation between separated surfaces of synostoses of the smaller joints and as a substitute for missing phalanges of the hands and feet.

Gillies says that cartilage for large cosmetic purposes in plastic surgery stands unrivalled. "It is available in sufficient quantity, is easily fashioned to the desired shape, and, what is most important, remains permanently in the shape and size in which it is imbedded, with the exception that if one perichondrial surface only is left, the graft tends to bend, the perichondrium occupying the cavity. The clinical evidence of the performance of cartilage graft is borne out by the experimental work of Staige Davis and by the histological work of Keith and Murray." Gillies adopted Nélaton's method of obtaining cartilage from the costal cartilages. The insertion of a cartilage graft may constitute a whole operation, or it may form a stage in a series of operations. When a softer contour is desired than would be provided by cartilage, local fat and muscle flaps are used to fill the smaller hollows. Gillies emphasizes the fact that the guiding maxim for plastic surgeons is that replacement of lost tissue by autologous graft should be as nearly as possible in terms of the tissues lost, *i.e.*, bone for bone, cartilage for cartilage, fat for fat, etc., etc.

FASCIA

Free autoplastic fascia transplantation was experimentally tested by Kirshner and clinically utilized as a support, and, in some instances, as a substitute for joint ligaments and for capsular segments; for the substitute of sinews and of the dura; for the strengthening of sutures especially in large hernias and the formation of aponeurosis for the purpose of the transferal of muscular function.

Lexer believes that the fascia lata from the outer side of the upper thigh are best adapted for these transplants.

Neuhof has reported very interesting experiments in the use of autotransplants of fascia lata for lateral defects of intra-abdominal vessels.

Neuhof believes that if the graft does not remain viable, the site of the defect must be occupied by a permanent resistant mass of connective tissue, smoothly lined on its inner surface and not encroaching on the lumen of the vessel. Five of his seven experiments on dogs were successful anatomically, functionally, and histologically.

I reported several months later a successful instance of a defect in the aorta of a dog corrected by a fascial transplant taken from the abdominal wall. Two weeks later the dog was killed and no evidence of leakage from the aorta, obstruction or thrombosis was found. The sutured vessel demonstrates a favorable result with a satisfactory reëstablishment of the blood-vessel.

In 1917, at the war front, in a suture of popliteal artery in a shell wound, I used a flap of fascia lata over the line of suture of the artery in order to protect the latter from erosion by the Carrel-Dakin tubes which were applied. This patient recovered.

FAT

Lexer used fat transplants for defects in the bone of the face and after operations on the female breast. They have also been used by Murphy to prevent the bone from growing together again after resection of synostosis in joints. Lexer and Murphy also used free fat transplants in the knee and the hip to prevent stiffening of the joint in ankylosis operations. Lexer had remarkable success in brain surgery with fat transplants for the repair of dura defects. The fat acts as a bolster between the scar tissue of the brain and the skull while tightly shutting off the subdural cavity. Lexer also reports the repair of a defect in the ventricle closed with a fat graft.

Fat transplantations were used extensively for scars by Halpern in 1913; by Souligoux and Cortés Ladó in 1915; by Guibé and Kanavel in 1916 and by Berretta in 1917. In 1921 Pennisi hastened the coagulation of blood in superficial wounds with fat transplants in dogs. Aseptic bone cavities were proved to be receptive hosts, and the fat transplant while in process of yielding to connective tissue was supplanted at the same time by the desired bone neo-formation.

KIDNEY

Carrel's experiments on kidney cited in the introduction were preceded the same year by the attempt of Ullman which was only partially successful. In 1905 Floresco performed the transplantation of the kidney in the cervical and inguinal regions in dogs, and in every case gangrene occurred.

In 1907 Stich transplanted the kidney into the lower abdominal region, the renal being anastomosed end-to-end to the iliac vessels, and the end of the ureter being grafted into the bladder. The circulation remained excellent, and macroscopical and microscopical examinations showed that the organ was practically normal.

Carrel's later experiments at the Rockefeller Institute showed that an animal which had undergone a double nephrectomy, and the grafting of both kidneys from another animal can secrete almost normal urine with its new organs and live in good health at least for a few weeks. This demonstrates that it is possible to reëstablish sufficiently the functions of the transplanted kidneys in animals.

In three cases of homotransplants of the kidney of one dog into the neck of another, I united the renal artery end-to-side to the carotid, but the stoma of the renal vein was placed end-to-end with that of the external jugular. This I consider very important because it creates immediate venous drainage of the transplant on account of the negative pressure in the jugular. Such positive drainage does not occur if the anastomosis is lateral. In these kidney transplants the Abderhalden method was used to seek the protective ferments in the blood which are brought into activity by the presence of a foreign transplant and which probably induce its final autolysis. The Abderhalden reaction was positive in eight specimens from dogs operated upon as above described in a series of homotransplantations in which the transplant invariably underwent degenerative changes with absorption.

Stich and Unger had no successes in the animal grafts with kidney. Borst and Enderlen only had negative results in dogs and cats. Jaboulay attempted in 1907 a heteroplastic kidney graft from a goat into a woman sick of incurable renal affection. The patient died.

Unger's attempt to transplant one kidney from an ape to a girl with severe hemorrhagic nephritis was a total failure as the girl died 32 hours after operation from pulmonary œdema. The blood circu-

lation in the ape kidney was established, but of course the question as to whether it functionated or not must remain open.

Dederer found in his autotransplant of the left kidney to the neck with right nephrectomy in the dog, that it is possible for the dog to remain alive and in good health more than four months after the transplant. He also observed that the quantity of urine from a cervical renal transplant is markedly increased after the removal of the other kidney.

Quimby observed that a single kidney which has been removed from the body of an animal and subsequently re-implanted can maintain normal life for an apparently indefinite period. Such kidneys are removed from control of the nervous system for a time and their function shows an initial period of over-action followed by balanced action. Quimby concludes that there is a strong suspicion that secretory nerves of the kidney do not exist.

Leo Loeb's heterotransplantations in kidney experiments showed a relative inactivity of the fibroblasts and a diminished mitotic proliferation. Species relationships play some rôle in determining the fate of the transplant.

Carrel closed this subject in 1913 by the remark: "It is quite possible that transplantation of the kidney may prove to have results vastly more interesting than appear likely at first sight. For the time being, I do not know how to tackle this problem."

NERVES

Duroux reported successes in hetero nerve grafts, but other transplant experiments for the bridging nerve defects were failures.

After Duroux, Sherren reported four successes in eight nerve transplants by the autotransplant and homotransplant methods, and Huber reported 37 per cent. of successes in 22 cases of heterotransplants. Assaky used nerve transplants in clinical cases. Adson reports a number of cases of the regeneration of peripheral nerves after injury by nerve anastomosis. In his technic, no covering is necessary if the freshened ends can be sutured in close apposition. If an intervening gap remains, it should be tubulized by fascia, and autogenous transplants may be considered for short gaps. The possibility for regeneration Adson considers very slight when three or four years' elapse between injury and repair or in cases of actual loss of nerve tissue or retraction of severed ends.

Cassirer and Unger had a remarkable case of nerve transplantation for the bridging of defects in the radial, median and ulnar nerves of the brachial plexus in a man gravely wounded. They used as graft the preserved nerve segments from the brachial plexus of a woman who had died on the operating table about fourteen days before. The nerves had been preserved in boric acid solution. After thirty-two months the motor function of the radial nerve was almost completely restored. The extensors of the fingers were again functionating and the sensitiveness of the radial nerve was improved. In this case the arteries had been shot through and the circulatory conditions were certainly not favorable.

Jalifier performed seventeen nerve grafts in war wounded with Nageotte's calf embryo nerves. He noted a certain partial regeneration of the cubital nerve in three cases, six, ten and seven months, respectively, after the intervention. In four other cases there were probably signs of regeneration of the cubital, posterior, tibial, and radial nerves, ten, eight and seven months after the graft. In four other cases which he followed up there was no improvement even ten months afterward. As in Cassirer's and Unger's phenomenal successes the good results in the nerve transplants were not observed until thirty-two months afterward, it may be that Jalifier does himself injustice by a premature report.

CORNEA

In the transplantation of the cornea, Ebling reports the results of Carrel's studies in homoplastic transplantations in cats. Carrel's technic consisted in fitting a very large rectangular flap like the door of a safe into the edges of the corneal opening, fixing it securely in its position by stitches. Ebling's most successful experiment showed a perfectly transparent cornea two years after the operation. The curvatures of the cornea with this technic appear normal.

The only recorded success in cornea transplantation in man is that of Zirm, who resected part of a leucoma and substituted for it a flap of normal cornea taken from the enucleated eye of a boy. About a year after the operation the patient could see through the transplanted cornea.

Fleisher studied transplantation of rat and mouse cornea and lens in the subcutaneous pockets in the guinea-pig, and found that the

epithelium of the heterotransplanted lens survives only twelve or fourteen days. The epithelium of the heterotransplanted cornea survives also only twelve to fourteen days while the homotransplanted cornea survives from thirty-five to forty days.

SKIN

Skin grafts are among the most successful clinical transplants. Oshima and Lexer first experimented with animals and then undertook numerous homoplastic skin grafts with fresh human material taken either from amputated limbs or from skin excised at other operations. These transplants almost invariably suppurated and were finally ejected by the host. Lexer was more successful in segments of epidermis taken from fresh foeti. Lexer had some success with animals with skin grafts by immunizing the host and the donor with their serum so that the section grafts lasted as long as eight weeks.

Schoene found that in animals from the same litter and of the same sex, skin grafts were successful. Carrel found in 1907 that yellow vaseline was the best preservative agent of skin. He found that by transplanting small bits of black skin preserved in vaseline in cold storage on to white dogs, the grafts took root and black bristles grew.

In 1913 Tuffier used Carrel's skin grafts in man and Carrel then sought to utilize for surgeons the waste material of lying-in institutions of foeti in a good state of preservation and of infants which had died at birth. The little fresh cadaver is washed with ether and then the skin is removed as a whole, cut in sections and placed in big tubes and put into the refrigerator at 3° C. The skin thus preserved remains in excellent condition for more than forty days. Carrel then used these grafts of preserved skin for dressing ulcers. He mixes paraffin, bees' wax and castor oil together, and pours it on the grafts which are placed like postage stamps on the surface of the ulcer. This paraffin mixture is removed daily and replaced by another coating.

Gillies has done wonderful plastic work in the repair of war injuries of the face for which he was prepared by his civil work in the repair of skin defects from lupus, syphilis, harelip, burns of the face and cicatricial ectropion. The principle of tubing the pedicle of a skin flap, has, in Gillies' opinion, pointed the way to dealing

with a reasonable loss of skin, traumatic or pathological, in any part of the body surface. Contractures should not be allowed to occur after burns. The impending deformity can be anticipated by a thorough excision of scar tissue followed by the use of skin flaps, tubed, say three weeks before, from the periphery of the defect. The end results shown by photographs in the war book more than justify Gillies' statements. It must be noted, however, that the use of skin flap grafts in plastic surgery is not confined wholly to the provision of a skin covering in Gillies' cases. In many cases the flap is used as a vehicle for the introduction of a cartilaginous support previously imbedded in it. Generally speaking, the base should be at least as broad as any other part of the flap. In the successes of skin grafts, the viability of the flap must be judged accurately in advance by the surgeon.

Mason's work in skin grafting was reported three years ago, and he states that he had made use of Moss' grouping of blood of the host and donor as suggested by myself in 1913.

OVARY

Knauer, Grigorieff, and Guthrie have shown that the transplantation of ovaries may be accomplished even without blood-vessel suture. Carrel and Guthrie first performed in cat ovary transplantations *en masse* with blood-vessel sutures which was successful.

Tuffier did 204 ovary transplantations in which autografts were only successful in women under 40 years of age. In four cases Tuffier removed human autografted ovaries from 2 to 3 years after they were transplanted and found incontrovertible evidence that they had been functionating. Tuffier concluded, however, that when the uterus is absent, ovarian transplantation is of no value.

In his work on ovarian transplantation in hens, Guthrie observed that from 6 to 12 months after the transplantation, the hens operated on are distinctly lighter than the controls. Also, eggs from hens operated upon weigh less than eggs from normal hens. As a rule, the weight of the egg and chick relative to body weight is also less in hens operated on.

Tuffier recently noted the painful monthly congestions of the ovarian transplant in woman and that the internal secretion of the ovary was plainly maintained, as in some cases the menses persisted.

When the transplants were placed in the uterus, pregnancies were even observed.

Mauclaire in more than forty ovarian transplants practically always observed the persistence of menstruation with metorrhagia, which was gradually regularized.

TESTICLE

G. F. Lydston in his experiments with the testicles in man had surprising results in therapy, but his transplants did not long survive.

Robert T. Morris has reported several cases of testicle grafting with fairly good results. In the first case the rudimentary testicle was stimulated into a remarkable development and establishment of potency. And in the second case the operation relieved the nervous symptoms, but had no effect on the loss of virility. In spite of his favorable results Morris concludes that heteroplastic grafting of any sort has not as yet been placed upon a satisfactory physiological basis.

Lespinasse, in 1913, reported his experimental testicle transplantation work. His method was that of "patching," *i.e.,* removing the section of the abdominal aorta, baring the opening of the spermatic artery and removing the piece of the vena cava, baring the outlet of the spermatic vein. Lespinasse performed an operation on a man of thirty-eight, one of whose testicles had been removed with a hernia operation and the other had been lost through an accident. The scrotum was opened high up and a bed prepared in the same way as for an undescended testicle. A slice of testicle one mm. thick from a normal man was placed in the scrotum, and another among the fibres of the rectus muscle, after stripping them of the epididymus, chord and tunica vaginalis. The wounds were closed without drainage and healed by first intention throughout. The result clinically was perfect. The man regained his virility completely, and, at the time of the report, these results had been present for two years.

Two years ago Lydston reported his work in testicular transplants taken from fresh cadavers. He cured several cases of sexual inversion, which were, however, plainly due to glandular insufficiency.

Stanley, of California, has also had remarkable results in his

homotransplantation of testicles taken from criminals. Lydston was the pioneer in this work, in which he was stimulated by the suggestion of Dr. John Murphy. Later Voronoff transplanted anthropoid ape testicles twice in eunuchs, but the cases are still under observation. This would appear on the surface to be a further confirmation of Loeb's results in heterotransplants when a relationship between the species apparently played some rôle in the success of the transplantation, but Voronoff's work has not conclusively shown any especial affinity between the chimpanzee testicle and man. His scientific reports are modest and conservative, and he remarked that real progress will be made only when these glands persist for ten, fifteen, or twenty years. It is possible that the Darwin idea appealed to the risibilities of the Parisian press reporters; and their wild accounts of our approaching rejuvenation by means of the Zoological Gardens inmates were erroneously ascribed to Professor Voronoff.

Steinach's operation of ligation of the vas deferens seems to have some beneficial effects in men with premature senility, provided their heart, lungs and kidneys are in good condtion.

BLOOD-VESSEL TRANSPLANTATION

Guthrie reported in 1907 that in rapid transplantation of segments of blood vessels in animals of the same species with only a short interval of anæmia of the segment as well as in heterotransplantation, marked histologic changes occurred in the segments. Ordinarily this consists of a dilatation of the lumen of the artery and thickening of the wall of the vein. Factors in these changes Guthrie believed to be alteration of the functional circulation, consisting of change of pressure in the lumen of the vessel and secondary alteration of the circulation in the nutritional capillaries, *i.e.,* in the vasa vasorum. Additional factors are complete abolition of the circulation in the nutritional capillaries; complete abolition of the lymph circulation, and complete severance of nerve connections. Guthrie thinks that in the case of the transplanted formaldehyde-fixed segments it is hardly conceivable that any cells could have survived, yet after a considerable interval it performs the mechanical function required of it.

Stich believes that in practical surgery, the transplantation of preserved blood vessels is not to be recommended, as thrombosis,

necrosis and infection almost invariably follow. Carrel, it is true, succeeded in implanting a human popliteal artery into the aorta of a dog. Fourteen months later there was a normal pulse in both femorals.

I found that autotransplants and homotransplants of segments of veins and arteries are perfectly practicable by Carrel's technic. While a tendency to degeneration of the transplant is indicated, the functional results of the transplant do not seem to be impaired. In my study of the histological aspects of the circular suture of blood vessels, Dr. William Clarke was inclined to hold that all transplanted tissue sooner or later undergoes connective-tissue infiltration and becomes replaced by the tissue of the host. Fibrous connective tissue will grow in and organize the blood clot, and the cells, which finally reach the surface will become competent to functionate as endothelial cells. The transplant acts as a scaffold for the support of the connective tissue of the host. There were seven successful homotransplants reported in this article.

We may conclude from this summary of the pioneer work in transplantation up to the final results of the last two years that transplantation of organs in animal is complete from the surgical side, but with Carrel, we must conclude that as yet these methods cannot be applied to human surgery for the reason that homoplastic transplants are almost always unsuccessful from the standpoint of the permanent functioning of the organs.

As Murphy has so truly said, the power of the organism to eliminate foreign tissue is due to organs such as the spleen or bone marrow so that when the action of these organs is less active, a foreign tissue can develop rapidly after it has been grafted.

The process, then, of leucocytic infiltration with connective-tissue degeneration in the transplant can be delayed for a certain length of time by the use of the X-ray, splenectomy or the internal administration of benzol benzoate, as shown recently by Peyton Rous, of the Rockefeller Institute. The transplantation of organs in man may at best be considered as a temporary adjuvant. Like the work in opotherapy, its results seem gropings in the dark with only isolated successes, few of which have been observed for the five-year period required for a surgical cure.

After forty-two years of effort in this field we have scarcely passed the threshold.

Skin, fascia, bone, nerve, fat, cartilage and blood vessels are clinically useful when implanted in the same individual or into the body of another individual, particularly of the same blood group.

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SHOCK AND FATIGUE WITH PULMONARY CHANGES

LECTURE OF DR. FENTON B. TURCK*

WHAT would have been your comment if you had actually known, before the World War, that the toxin from damaged tissue in the human body caused traumatic shock and death? What answer would you give now, if you were absolutely sure that toxæmia produced by ordinary tissue disintegration causes disease and death?

Before waiting for your reply, I wish, first, to acknowledge the honor conferred in your permitting me to present the subject of my address before this General Session of the Canadian Medical Association; and, second, to ask whether it was some conscious purpose, or merely coincidence, that brought together the pathological specimens of your War Museum and our animal specimens, experimentally produced, which show similar lesions caused by tissue-toxin.

On one side of your War Museum's pathological exhibit is a tragic display. This unfolds the destructive effect to the human body of tissue damaged by shell, gas, exposure, or fatigue. On the other side are exhibits that present the same tragic story. They, too, are records, of the effects of damaged tissue-toxin upon animals, but produced experimentally in the laboratory.

As valuable as studies in symptomatology and human pathological anatomy may be, little scientifically can be learned from these alone. What advance we have made in biology, on whose principles the science of medicine rests, has been achieved mostly through experiments on the lower animals and on plant cells. The demonstration of the etiology and pathology in these experiments, with gross specimens and carefully prepared microscopical slides from hundreds of animals and plants, carries the imagination even beyond the grim and silent evidence presented in your War Museum. If this were not so, the solution would seem hopeless.

The scientific discovery of the cause of shock and its application in the World War taught a great lesson of utmost importance to practical medicine. How shall we describe it so that even the wilfully

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ignorant shall be forced to see it and be persuaded to apply this knowledge daily for the general welfare in conserving health and life? If the discovery of the actual cause of shock can be brought to our comprehension, it should prove the key to open our understanding of the mysterious reactions that occur continually within the structure of the body's living cells.

Surely, we realize by this time that the live animal is only a group of cells. Shock, also, has been shown to be nothing but a phenomenon of the dynamics of the cell. It has been a difficult problem to arrive at the discovery of the cause of shock, its value and importance. But, the cause once known, its significance in the science of medicine at first sight has a kind of covert and occult, rather than an obvious, meaning. But its real, or actual, significance has been practically and fully illustrated in the vast number of cases of war wounds.

Let me ask, Why should an injury to a limb, for instance, affect the entire body of a man? The answer is obvious.

Again, illustrating the same principle, "When a crustacean, like a lobster, injures one of its limbs or claws, nature permits the animal to throw it off like a cork leg and, in addition, to grow a new one in its place, that the injury may not affect the entire body." The lizard, upon injury of its delicate tail, disposes of it quickly, and a new one soon takes its place—a protective measure against shock. Shock follows in other animals when the living injured member is allowed to remain attached to the body. The mere detaching of the injured limb stops shock and death, which are liable to follow if the member is suffered to remain.

The injured branch of a tree is cut off to save the tree from destruction and death. Where several branches or shoots undergo disintegration from any cause, we prune, trim, or dress the plant or tree. The pruning of the unhealthy parts, the clearing away of useless material, saves the whole tree or plant from disintegration and death.

The catalysis following any injury depends, of course, upon the degree and form of injury. An open wound produced by shrapnel from a bursting shell, or tissue crushed without breaking the skin, presents a condition where disintegration of these and of the adjacent cells quickly follows. This is, then, in turn, followed by shock symptoms and death if the injury has been sufficient to cause rapid and

extensive disintegration of tissue. If the injured limb or part be pruned or cut out soon after the injury, the shock symptoms do not develop, and the victim of the injury is saved from death. Deep, crushing injuries, with the skin unbroken, as I have said before, often cause the most serious shock symptoms and death. Sometimes, when only two hours have elapsed after the injury, it is too late to intervene—so quickly does the product of disintegrated tissue overwhelm the victim. Bowlby says, "It is a race against time." For instance, as in snake poisoning, if the injured, disintegrating part, where the poison is located, be cut out promptly, life is saved.*

Experimental animals, in shock induced by local injuries, recover on removal of the injured part; whereas, if the injured part is not removed, they uniformly die of shock. If a crushing injury is very great, the shock symptoms are correspondingly very marked. But amputation early anticipates a fatal result, and thus life is saved. Larry, in the Napoleonic wars, said: "The commotion (shock) disappears after early amputation." If the soft parts are injured, the cutting out, or trimming, of the affected parts (*débridement*) likewise prevents the shock symptoms and averts death.

The removal here of an apparent cause and the prompt disappearance of the usual effect are so closely related, and so apparent to the thinking mind, that this scientific reproduction of injury and shock in animals has led to the irresistible conclusion that a great fundamental principle is here involved and its discovery unfolded. (See bibliography.)

With the understanding of this principle, which one may verify by repeating the same experiments, we can explain why crustaceans, throwing off an injured limb, save themselves from death, and are capable of a renewed life. We may also comprehend why, when plants and trees have been pruned, life is preserved—why *débridement* averted shock and enormously lowered the death-rate from wound injury in the recent war from 75 per cent. to 9 per cent.

But let us ask if the principle I have mentioned is applicable to all living animals and plants. The tree has no nervous system, yet it suffers from an injury to a part the same as animals do. And, knowing this, the tree-surgeon by his act of removing the injured, decaying, and disintegrating parts, has—but perhaps unconsciously

* See literature, *N. Y. Med. Jour.*, 1896, "Toxins Acted Like Snake Poison."

—the same principle in mind as the human surgeon, in removing injured parts and bringing together only the tissues that are normal —thus preventing further disintegration.

What is the significant thing that happens to the body after an injury and devitalization of a part? Locally, we know that disintegration follows the initial disturbance—whether the wound be closed or open. Crushing injuries are the most prompt and inexorable in producing the sequence of disintegration, shock, and death. Disintegration is the natural outcome of a condition of dead or dying tissue. Just as living tissue is self-propagating, so dead tissue is self-disintegrating. The ferments in the tissue cells digest the dead and dying tissue—a process which is termed autolysis. When disintegration, self-decay, or autolysis, takes place, the particles of disintegration have always been regarded as the element of danger to the health and life of plant or animal, whose entire body becomes affected by these particles.

In order to become sure of this fact, it was necessary, first, to produce such injuries experimentally, and then to observe the disintegration that followed, and then to know that the particles of disintegration were all being absorbed by the system; then to perceive and verify the shock symptoms which inevitably ensued, by general observation, and by the fixing of the pathological picture on microscopic slides. This I have already done.

By taking up the particles of tissue disintegration with a little water and injecting the infusion into the animal from which they are taken, the death of the animal is immediately effected. If the infusion, or tissue extract, is injected into another animal of the same species, not previously injured, it reproduces the identical shock symptoms noted in the injured animal and is followed by death.

After getting these facts fixed firmly in our minds, we are better prepared to understand why an injury to a limb should affect the entire body, and why the phenomenon is autochthonous. The symptoms can be examined into by instruments of precision measuring temperature, blood-pressure, and by microscopical evidence of the changes of the circulation, especially that of the viscera *in vivo,* and even that of the minute blood-vessels, studied through the lens under various magnifications. This we have done and the results have been measured and recorded.

The tissues, such as those of the lungs, liver, and upper alimentary tract, *in vivo* and *postmortem,* have been examined for the determination of the pathological changes that have taken place; and these changes have been accurately described.* But before the practical application of the principle illustrated in shock, we must follow the fatigued, exhausted victim of exposure suffering from comparatively slight injuries that but mildly affect those that are normal.

Is it possible that fatigue toxin is the same as shock toxin? What is the first direct symptom observed in all animals or in man when in a state of shock? It is extreme fatigue or exhaustion. Can we, by injecting animals with the particles of disintegrated tissue produce fatigue in the same way we have produced shock? The answer is, yes. Not only have we done this,† but we have found that the severity of the symptoms is in direct proportion to the strength, or concentration, of the disintegrated tissue particles.

Again, does extreme exposure break down tissue as mechanical injuries do? The answer here is yes. For we have found that excessive heat or cold causes autolysis with the same pathological results following, or in inanition we have what is known as the "toxæmia of starvation," which is due to tissue poison liberated by autolysis. We may therefore link up the phenomena of shock with those of fatigue and say they illustrate a pure biological, physiological, and pathological reaction. In other words, the biological rôle of autochthonous tissue-particles takes the centre of the stage in the play of life. In the late war, all soldiers, even in severe shock, did not die. Many who were fatigued to complete exhaustion did not die. Recovery from fearful exposure was common. In explaining, we say they were more resistant than those that died. When we use that expression, we mean that they were more immune. When we use the word immune in this biological sense we refer to natural immunity. We mean there was sufficient antitoxin within their own

* Pathol. Lit.: "Congestions and Stagnation of the Finer Splanchnic Vessels Observed with the Lens," *Jour. Amer. Med. Asso.*, June, 1897. The presence of this condition was found to be due to physical causes. Agglutination and prompt coagulation were noted, which brought about stagnation. Turck, "Shock Produced by General Anæsthesia," *Jour. Amer. Med. Asso.*, May 2, 1903.

† Fatigue Lit.: Turck, "A Study of Fatigue in Gastric Muscle," *Proc. Amer. Gastro-Enterological Asso.*, Wash., D. C., 1903; *Medical Standard*, Chicago, Dec., 1903.

bodies to enable them to tide over against their own tissue-toxin. Hence, the recovery.

The antitoxin here referred to acted as a specific against the toxin which had produced the condition of shock, or fatigue, or exhaustion, or other symptoms of a metabolic nature.

This natural antitoxin is in the blood of every animal, and it is specific only to an animal's own tissue-toxin or to that of an animal of the same species. While this natural specific antitoxin is found sufficient to neutralize the toxin of ordinary tissue break-down, occurring even under shock conditions; on the other hand, when there is a failure toward complete recovery, it is due to a deficiency in quantity. Realizing that this was so, we proceeded on the principle involved, and produced by inoculation of the tissue-toxin chronic metabolic diseases in our experimental animals. By reducing the animals' natural immunity, we were able to produce one form, and by increasing the tissue-toxin above their normal antitoxin, we produced another group of chronic diseases.

The cases of exposure, fatigue, complete exhaustion, and shock in the late war, though often saved from death, did not all recover their normal health. Though possessed of sufficient natural immunity, that is, just enough units of their own natural antitoxin to ward off death, they did not possess enough to permit complete recovery. They therefore passed into a stage of chronic metabolic disease; because they lacked sufficient natural antitoxin in their system to overcome completely their own tissue-toxin.

Knowing this, then, when treating such cases, our attempt should be to increase the natural immunity by supplementing it with an antitoxin obtained from sources other than the patient's own body, which we have done in our own practice. Many years ago I demonstrated that heat at a high temperature increased the natural antitoxin and thus helped to fortify the patient against the shock toxin (1898, 1900, etc.).

In fatigue experiments on animals, we found that the toxin of fatigue was neutralized by fatigue antitoxin, the latter also increasing the natural immunity against fatigue (1903).

For this reason we devised the production of an antitoxin against shock-fatigue and general metabolic disorders. Active immunity was produced by injecting repeated small doses of the tissue-toxin infu-

sion, or extract, into animals at regular intervals, about once a week or ten days. The blood serum of the immunized animal was injected into a non-immunized animal, which resulted in passively increasing its natural immunity.

Furthermore, we produced an antitoxin of high potency by injecting larger animals with tissue-toxin of other smaller animals of another species. Thus, by inoculating goats with cats' tissue-toxin infusion, or extract, at regular periods—first twice, then once a week for about one year—the goats produced an antitoxin highly specific for the cat. By combining both active and passive immunizing materials, a high degree of immunity was established in these animals.

All other species of animals experimented upon were rendered immune in the same way. These experiments proved two important biological principles: (1) The tissue-toxin stimulates and increases the natural antitoxin if given in small doses; and (2) the antitoxin is the body which adds to and supplements natural immunity. By injecting horses with human tissue-toxin, antitoxin is produced. This I will refer to later. I think we now have a better understanding of what is meant by tissue-toxin, true auto-intoxication, and true antitoxin, which adds to natural immunity.

What a change has come over the medical profession since my first presentation, in a paper in Canada, of this same principle fourteen years ago! The biological reaction of the individual to his own tissue-toxin was not so fully appreciated then as now. Thus, in 1897 (*Jour. Amer. Med. Asso.*, p. 1163, 1897), in a discussion of my work on "Shock Toxin," Kiernan said, "I cannot but take issue with the position that local tissue changes, irrespective of nerve action, underly the results, as Doctor Turck has claimed." This expression records the fact that my discovery, based on my experiments on animals, while not accepted, was understood at that time. Furthermore, this contention of Kiernan's expressed the opinion that generally prevailed up to the early stages of the late war. But Jeanneney, of the University of Bordeaux, who had made extensive studies on *"Choc Traumatique,"* * deplored the fact that, although the cause and treatment of shock and allied conditions were already known and estab-

* Since the delivery of the present address before the Canadian Med. Asso., July, 1921, Jeanneney has published his work on *"Choc Traumatique."* In this he gives a résumé of my work on shock and allied conditions from 1893 to the present.

lished; yet, owing to stupidity or dulness, this knowledge was not utilized in the beginning of the war. In addition, speaking in a personal way, he says, referring to my writings on the subject, "It is a pity that those most interesting works were not sufficiently known in France when the war began. A lot of researches and time would have been spared and a great many lives saved."

Doctor Cabot (1921), who has just preceded me, has called your attention to "the fears we now have of tissue-toxins producing disease." We did not have these same "fears" when I presented my paper, above referred to, on "The Effects of Autolysis," in 1907, before the Pathological Section of the British Medical Association at the Toronto meeting.

The swift changes of war brushed aside dull stupidity, and brought stupidity's enemy, an experimental creative fact, to the fore, and applied the newly acquired knowledge to the saving of life.

Professor McCloud, of Toronto, has reviewed the entire biological phenomena involved in shock, and shows how secondary or chronic conditions follow. He demonstrates how the condition of shock "causes the blood corpuscles to become contiguous, so that they have a tendency to jam in the capillaries and so lead to progressively increasing under-nutrition of the tissues and the production of more toxic material." * He adds, "The above conclusions are more or less confirmatory of those drawn several years ago by Turck,† to whom credit is due for being the first to suggest the toxic element as a causation factor in shock."

By the asphyxia of the cells, resulting from splanchnic congestion and stagnation, we see that death must ensue from inanition. The cells in their turn produce an added amount of the same tissue-toxin that first caused the capillary stagnation in the beginning—no new

* This blood stagnation was clearly defined as a physical change in the blood by me in the nineties ("Shock," *Jour. Amer. Med. Asso.*, June, 1897). In the discussion of my paper Ballenger stated (p. 1163), "Doctor Turck's experiments upon animals are very instructive, showing the physical changes which take place in the blood in conditions of shock." This also records the fact that not only the cause of shock, but the pathology of shock demonstrated by my experiments was clearly understood at that time (1907), though not receiving general acceptance.

† *Jour. Amer. Med. Asso.*, June, 1897, p. 1160; *Chicago Med. Record*, May, 1902, p. 450.

cause has arisen. The same phenomenon occurs—but more slowly and insidiously—in many cases which develop into the chronic stage.

We wish to know how an acute tissue-breakdown becomes self-perpetuating. We may also ask how an acute phase of tissue-breakdown passes into a chronic phase. But, when considering this question, we must remember that a great change has at last taken place in our concept of the pathogenesis of the chronic as well as the acute phase of metabolic diseases. In the light of our new concept, even the dullard must foresee how a condition in the chronic phase similar to that which occurs in the acute stage is bound to be present. The same experimental research that led to and developed our concept of acute shock and other similar conditions also brought to our knowledge the underlying cause and general pathology of the many chronic metabolic diseases we encounter.

Before following our research work into the domain of acute diseases, into the varying phases of chronic disease, we must compare the former ideas, the comparatively recent status of the subject, with the newer development in scientific medicine. When it was discovered that the settled opinions on shock and allied conditions were wrong, a change of views was forced upon all alike.

The collapse of our former theories in influenza and pneumonia was like the shock of a revolution. When Colonel Vaughan * despairingly complained that "so far as respiratory diseases are concerned, we know no more than our ancestors knew a hundred years ago; and we may as well admit it," classic medicine, resting in conformity with the best authority, received a terrific jolt.

The St. Andrew's Institute of Clinical Research † attempts to come to the rescue of "this disheartening condition" by suggesting a new classification of medicine into six groups. The admission is made that not in any one of these groups of diseases are the causes known. The same situation is recognized in surgery. Not only is the appeal made to the internist to share the responsibility by a "prolonged after-treatment"; but, as Sauerbruch * affirms in his recent report on "Recent Advance in Surgery": "No epochal advance

* *Jour. Amer. Med. Asso.*, Dec. 21, 1918, vol. lxxi, No. 25.

† St. Andrew's Inst. of Clinical Research: Lancet, Sept. 10, 1921.

‡ Sauerbruch, "F. Beiträge zur Klinischen Chirurgie," Tubingen, 1921, 122' No. 2, p. 234.

has been made in surgery for a quarter of a century." He concludes, "No advance is possible until we know more of diagnosis." Now, diagnosis depends on etiology; hence we cannot hope for progress in this until we know more of etiology; and for etiology, the science of the cause of disease, we must knock at the door of the experimental laboratory.

Unless we continue to do so, we may have to conclude that our Western philosophy is based, as it seems to be, on the classic Græco-Babylonian idea of some evil spirit that has gotten into us which should be exorcised. The true Far Eastern philosophy differs from this. Our ultra-modern views in scientific medicine are strangely similar to the most ancient beliefs concerning the mystery of life. It is singular that we should revert to the most ancient Chinese civilization for the beginnings in our most modern conception of biology. It is true, our present knowledge is derived purely from recent experimental research, but the idea is really Chinese. Professor Hirth * (perhaps one of the greatest authorities on the ancient Chinese philosophy before the advent of Buddhism) calls our attention to Fu-Hi, 2852–2738 B.C., who first enunciated the principle that all living matter was actuated by the interaction of two opposite forces represented by the male and female element in the whole of nature. Hirth refers to the invention of Pa Kua, representing this by the eight symbols, each consisting of three parallel lines broken or continuous. The continuous line represented the male element in nature and the broken line the female. Hirth then concludes: "For all their attempts at fathoming the secrets of nature are based on the idea that male and female powers are inherent in all matter."

Our present conception of the negative electron as well as of the positive proton in the atom followed upon the discovery of radium by the Curies, but the "positive" and "negative" electric charges which play the rôle of life within the animate cell are but an application of the ancient Chinese philosophy.

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* "The Ancient History of China to the End of the Gohn Dynasty." See, also, *Ency. Britt.*, 11th Ed., China, Vol. vi, pp. 191-194.

NOTE: Babcock (W. W.), *Ill. Med. Jour.*, Dec., 1921, p. 444, claims that "over a third of a century has elapsed since hardly a single method or principle has been developed." He also says, "Surgeons have created a new field of pathology, and the treatment of symptoms resulting from operations on the stomach now looms up large."

As biologists, we are a tribe of ancestor-worshippers; for we go back in evolution to the single cell, the protozoa, and religiously study it and apply the knowledge we have gained to practical medicine.

Modern medicine is based on our knowledge of the science of biology. The greatest gains in our recent knowledge in biology have come from the study of the cell, its growth, its metabolism, and its abnormal variations. These facts are at the very foundation of normal and abnormal conditions in the higher animals, including man. To understand the transition of acute abnormal conditions to the chronic phases of disease, we must proceed in the same manner and by similar methods of experimental research through which we were able to solve some of the mysterious phases of acute diseases.

To make this perfectly clear, I must here refer to our laboratory procedure, whereby we have been able to produce chronic metabolic disease in animals, just as we have caused shock and other acute metabolic changes. We now have in our possession two elements, one the tissue-toxin which produces the poison action, the other the immune body which opposes the tissue-toxin in the animal. By production and use of the specific antitoxin we have been able to demonstrate that tissue-toxin is the cause of both acute and chronic disease. We are able to induce a great variety of chronic diseases by varying the relation of tissue-breakdown to the antibodies in the animals. As I have repeatedly demonstrated by experimental methods, to produce disease we must either reduce the natural immunity or increase the tissue-toxin.

There comes a period in the life of man where no amount of antibody will entirely overcome or neutralize the tissue-toxin of tissue-breakdown and prevent disease, otherwise we might be immortal. Furthermore, there is a constant normal breakdown. It was in accordance with this principle of deficiency of antibodies that various forms of chronic disease were experimentally produced. While there was enough antibody to prevent death from acute symptoms, this was not enough to prevent chronic disease from tissue-breakup.

As the tissue particles are all derived directly from the cell, we have named the tissue-toxin (particles of cell necrosis) "cytost" and the opposite natural immune body "anticytost," from cytos, a cell.

One advantage we have now is that we are in possession of both cytost and anticytost, and we may apply for illustration the Chinese

designation: For cytost—the "male element," and for anticytost—the "female element."

Our researches have shown that low concentrations of cytost stimulate cell growth and metabolism, medium concentrations retard these processes; and, finally, high concentrations interfere with cell life to such an extent as to produce dysfunction, leading in the end to a complete standstill. In our every-day language these phenomena are identified by the names of various diseases, according to the chief clinical symptoms or to the structure first showing signs of altered function. When the intensity of the reaction has stopped all cell activity, the result is, of course, death.

The action of cytost is counteracted by the substance termed anticytost, which is present in all cells and body fluids. Life and health, that is, normal functioning, depend on the delicate biological equilibrium maintained between these two opposite elements. The reaction between cytost and anticytost represents the mechanism of immunity.

The balance of this reaction may be disturbed either by a deficiency of anticytost, a condition termed lack of immunity and resistance, or by an excess of cytost, produced by exterior accidental events, such as shock or any agency destroying tissue.

The clinical methods of increasing anticytost consist of passive immunization, as by the application of heat and transfusion of blood from healthy animals, or by active immunization, as by the injection of small doses of homologous cytost, or the production of limited tissue destruction at appropriate intervals of time. An important improvement in these methods was rendered possible by the production of a serum containing a high concentration of anticytost. This advance was effected during the war by injecting increasing doses of human cytost into horses for the period of one year. This serum has since been utilized extensively in clinical practice for the production of passive immunity and as an important aid in inducing active immunization.

In the following I shall give an outline of the experimental work which I have carried out from the early nineties until the beginning of the war. By quoting typical and representative experiments, it will be shown how the research evolved in logical sequence crystallized in the establishment of a new biological principle on a strictly scientific basis. In the preceding lecture I have recorded an

important application of this principle in the case of shock. In numerous other experimental and clinical reports I have shown its therapeutic significance in disorders such as pneumonia, rheumatism, arthritis, neuritis, peptic ulcers, nephritis, arterio-sclerosis, and pregnancy toxæmias.

In tracing the progress of the experiments extending over twenty years, it will be seen that the active agent studied was the same throughout, although it was termed shock toxin, or fatigue toxin, or muscle bouillon, when the problems of shock or fatigue occupied my chief attention. All these terms are now merged into the designation "cytost" for convenience of description.

CONNECTED RESUMÉ OF AUTHOR'S RESEARCHES

The earliest observations reported were in a patient with shock-like symptoms suffering from auto-intoxication. It was found on examination that he was using alcohol in excess, but had stopped it for three months, and the symptoms of auto-intoxication continued. The outstanding features were marked prostration, sluggishness of the peripheral circulation, cold hands and feet, and dyspepsia with vomiting. The excessive use of alcohol had produced cell necrosis and the intoxication effect of the products of this process continued after the alcohol had been stopped. These observations were confirmed by experiments, using various agents to produce cell necrosis.[1]

In 1894,[2] at the International Medical Congress, Rome, I reported experiments on various animals, dogs, cats, rabbits, monkeys, etc. (They were also published in the *Wiener med. Wochenschrift,* Nos. 1 and 2, 1895, pp. 8-10.) Application of various cauterizing agents was made with an instrument called the gyromele. The agents used were tannic acid, nitrate of silver, and chromic acid. Irrespective of the agent applied, cell necrosis was produced. This was proved by removing with the gyromele at intervals the material which had collected on the stomach wall. The etiological significance of the organisms was investigated, but "in all these experiments no specific infection could be demonstrated."[2] The absorption of this material produced local effects on the stomach wall. These changes were determined at regular intervals by removing portions of the mucous membrane from the wall with specially designed "nippers," and sections were made for microscopic examinations.[15] Changes observed were of an acute and chronic nature according to the stages.[7] The chronic

changes observed were those of atrophy, finally affecting the muscles as well, resulting in myasthenia.[11] More violent and general effects were produced by the use of an agent that effected a greater degree of cell destruction in the stomach,[1,2,3] mustard oil.[44] Comparative records of the local and general effects resulting from these experiments were presented in the *Proceedings of the American Gastro-Enteric Association,* 1900.[36] To determine with exactness what these general effects were, the accumulated products of cell necrosis were withdrawn from the stomach during the fasting condition and injected into other animals. In all these cases sterility was insured by passing the fluid through a Pasteur filter.[10]

SHOCK TOXIN RESULTING FROM WOUNDS AND OTHER FORMS OF TRAUMA

Another method of approach was to cause cell necrosis by producing surgical wounds and exposing the peritoneal surface to the air to cause cauterization by desiccation. "In these experiments the color changes in the abdominal viscera were noted, the blood-pressure alterations were measured in both arteries and veins in the peripheral as well as the splanchnic circulation." [19]

EXPERIMENT No. 7.—"Shock produced by operation on abdominal viscera. Long incision from xiphoid appendix to symphysis pubis. Operation for gastrostomy (Turck's valve operation). Operation for the Heicke-Mukilicz pyloroplastic. Also Martell's operation for gastroenterostomy. Within one hour the entire stomach and intestines showed a bluish color with all the veins congested. Respiration shallow; pulse, 130; evidence of collapse." [19]

EFFECTS OF SHOCK TOXIN

EXPERIMENTS Nos. 5 and 6.—"Stomach contents were drawn off from a patient suffering with dilatation of the stomach. One hundred cc. were injected into a dog weighing 15 kg. This is repeated in one hour. Evidence of shock observed. In one hour the surface was cold, the mouth and gums pale, and on opening the abdomen a deep injection of all the viscera was apparent. The animal was in shock. Introduction of the intragastric resuscitator; reduction of the shock is produced. The animal recovered. While in a control under the same circumstances carried out on a dog weighing 16½ kg. the animal died." [19]

In experiments 1 and 2 [19] the method of producing shock was by combined mechanical, physical and chemical injury of the tissues. This resulted in the usual cell necrosis and liberation of the "shock toxin." The resulting respiratory and circulatory changes were studied. The blood-pressure was taken (with a manometer) to

indicate the changes in blood-pressure. This was combined with direct inspection of the splanchnic vessels. Long abdominal incision and extensive operation on stomach produced considerable wound trauma. The rough handling was the mechanical injury; exposure to air caused desiccation (burn) and rapid loss of heat, and thus produced the physical injury; chloroform, a "cellular poison," acted as the chemical injury. When blood stagnation occurred and shock was produced, heat at a high temperature (130° F.) was applied directly to the splanchnic zone. This caused promptly a reversal of the shock condition.

"This was repeated during the same period and the same phenomena were again presented." [19] "When the restoration of the circulation seemed assured, the abdominal wound was closed, leaving a permanent gastric fistula. The animal recovered and was exhibited in my lectures given at the Jefferson Medical College, Philadelphia, February, 1896." [15]

Method of Separation and Extraction of the Shock Toxin.— The attempt to recover the "shock toxin" which produces shock was not successful by any known chemical means. But, as stated in the Jefferson Lectures (1896),[15] published in the *Medical News,* April 4, 1896, "I have, however, taken advantage of the fact that coagulation of various albuminoses takes place at different degrees below the boiling point (100° C.). By producing a vacuum over the filtered fluid taken from the stomach, a rapid evaporation takes place by heating to 60° C., to 80° C., to 90° C., and up to 100° C. Passing this material through a Pasteur filter [10] and injecting the filtrate into animals produced first slight tottering movements, then dragging the hind legs. The toxic effects were the same in some respects as those observed in rabbits bitten by a venomous snake. The animal died within three hours. The coagulated residue injected into animals caused their death also."

COMPARISONS MADE BETWEEN SHOCK TOXIN AND DIPHTHERIA TOXIN

Comparisons between the effects of the "shock toxin" obtained from the interior of the stomach and diphtheria toxin were also made. The effect was similar in its pathology as well as in the symptoms of shock when injected into the veins or into the stomach wall or intestines.[50] Congestion was found internally.

"SHOCK TOXIN" OBTAINED FROM THE EXTERIOR OF STOMACH WALL (PERITONEUM) COMPARED WITH THAT FROM THE INTERIOR (MUCOUS MEMBRANE) OF THE STOMACH

Not only were the shock toxins obtained from the interior of the stomach, but also from the exterior wall. Cell necrosis in this case was produced by exposure of the viscera to the air and by traumatic injury of the visceral peritoneum and of the muscle wall. This caused the accumulation of the particles of necrosed cells in the peritoneal fluid. Sufficient time was given for the necrosis of the tissue. This material was collected with the peritoneal fluid and injected into animals. Blood-pressure records were taken and biologic reactions in vitro and in vivo observed. These experiments showed the manner in which congestion occurred resulting from agglutination of the corpuscles in the vessels. This was shown particularly by the following four experiments.[45]

EXPERIMENT No. 1.—"Jan. 3, 1902, dog, black mongrel, weight 13¼ kg., temperature 105, 3 P.M., inserted the canula into the femoral artery connected with Hall's tambour for hæmographic tracing. Blood-pressure, 145. Opened abdomen, exposed viscera to draught of air for the purpose of producing shock, handling the viscera roughly. At 4 P.M., blood-pressure, 130; 4.30, shock marked, pressure 120; 4.45, temperature 102°, pressure 105; 5, profound shock, pressure 80; 5.15, no pulse tracings, animal bled, recovered 150 cc. of blood, which presented a laky appearance. Blood serum taken from the peritoneal and pleural cavities."

EXPERIMENT No. 2.—"Injected serum from dog No. 1 into the femoral vein of dog No. 2. Temperature, 39° C. The animal showed signs of shock with anæmia of the surface and dyspnœa. Temperature, 37° C., animal trembling. Following day the animal showed evidence of shock, was stimulated by heat and gradually recovered. The serum from the peritoneal cavity after the cauterizing effect of desiccation contained the 'shock toxin.'"

EXPERIMENT No. 3.—"Injected 50 cc. serum from a dog suffering from shock. Within twenty minutes there was diminished respiration and falling blood-pressure. Temperature in the beginning registered 40° C. Temperature reduced to 38° C. Dog showed no marked signs of collapse after suturing the wound. Later, the dog became listless, respiration shallow, pulse weak, thirst intense. Five days afterward the animal completely recovered."

EXPERIMENT No. 4.—"Serum from dog with shock used to show the effect on red cells of a healthy dog. Cover glass preparation, hanging drop of the 'shock serum' mixed with fresh red blood cells. Small areas of glutination observed in twenty minutes. The peripheral cells showed shadow corpuscles. The central zone did not show such marked hemolysis. Serum mixed with red blood cells presented a laky appearance in test tube after being placed in incubator for thirty minutes."

Similar experiments as the above were carried out (30 experiments) and presented before the Pan-American Congress in 1902.[53]

As we have seen, exposure of the peritoneum to air causes desiccation, which rapidly extracts water from the cells, resulting in their death. (Cell necrosis and the formation of "shock toxin" in the peritoneal fluid, and the injection of this fluid, caused shock.) This desiccation is in effect a cauterization burn of the tissues. The products of cauterization of tissue act the same whether exterior or interior of the stomach or intestinal wall. The following experiments illustrate the effect of a burn of the stomach and colon in producing shock and collapse:[36]

EXPERIMENT No. 15.—"Dog under anæsthetic. Heat introduced into the stomach at 65° C., which for the first ten minutes caused contraction of the splanchic vessels. In fifteen minutes there was observed marked dilatation and at the end of twenty minutes venous engorgement, with marked hyperæmia of the splanchnic area. This was followed by rapid heart-beat with complete collapse at the end of thirty minutes."

EXPERIMENT No. 16.—"Dog under anæsthetic. Water injected into the colon at 68° C. This was continued for thirty minutes. Marked splanchnic congestion followed with collapse. The animal recovered from the anæsthesia, but died next day. Observations showed a sloughing of the mucosa of the colon.

"Burns of the peritoneum at a relatively low temperature, but prolonged, caused shock and death."

EXPERIMENT No. 28.—"Dog; the abdomen was opened and hot-water bags placed in the abdominal cavity for one hour and twenty minutes. The temperature of the hot-water bags was 58° C. Result: animal died within twenty-four hours. Postmortem showed blebs on the intestines resulting from the continued application of hot-water bags at 58° C."[35]

The degree of the temperature to produce desiccation of the tissue —a burn—varies in different locations of the body. This is clearly shown by the application of heat within the stomach at 65° C., within the colon at 68° C., and within the peritoneal cavity at 58° C. The length of time of the application of the heat is also a factor in causing cell necrosis and the liberation of the "shock toxin."

ANTITOXIN AGAINST SHOCK AND INFECTION

One of the most striking evidences of the toxic origin of shock was deduced from the experiments in producing an increase in natural immunity. These experiments were carried out by injecting animals with a serum taken from animals that had recovered from shock. It was also found that high temperatures applied to the splanchnic

area increased the natural immunity in much the same way as did the antitoxin serum injections. It was further shown that *bacteria* added to the "shock toxin" caused more rapid death, and in addition it was demonstrated that these same methods of increasing the natural immunity protected from shock and "infection." These facts are stated in the conclusions drawn from a group of experiments reported at the Pan-American Congress, 1901, published in 1904.[53]

"In another series of experiments I found that when an animal is stimulated by heat applied within the splanchnic area by methods previously described, immunity or resistance against infection was thus produced. When the serum of such an animal was injected into another animal there was an increased resistance produced, or a partial immunity to infection. Animals so protected could not always be saved, but the death from infection was retarded sometimes for one or two weeks. These facts establish a most important point in the pathology of shock, namely, the alteration of the tissue cells and blood in shock."

This *"post hoc"* evidence has proved of much advantage in the control experiments in the production of shock from "shock poison" and is presented with the protocols as evidence as the toxin-antitoxin reaction.

The same tissue-toxin and the same resulting phenomena of shock occurred whether the damage of the tissue was produced inside or outside of the visceral wall. The tissue-toxin and the phenomena of shock varied with the degree of damage to the tissues and the "dosage" of the poison. This quantitative evidence gave additional value to our findings. It was found also that when the muscle tissue was damaged it produced the identical results. To make sure that muscle degeneration had occurred, the fact was confirmed by the microscopic examination of the damaged tissue.[47] The tissue-toxin and the resulting phenomena of shock and fatigue were constant and only varied with the degree of natural immunity.[47] The variations in "dosage" of the tissue-toxin and the degree of natural immunity were within the grasp of experimental control. This had enabled me to obtain direct evidence that the tissue-toxin was the cause of the phenomena observed. Among all the symptoms noted, none was more prominent and constant in appearance than fatigue.

As clearly defined in a report on experiments on shock in the

transactions of the Pan-American Congress,[53] "These facts establish a most important point in the pathology of 'shock,' namely, the alteration of the tissue cells and blood in shock."

RELATION OF "SHOCK TOXINS" TO FATIGUE TOXIN

"In a large number of our experiments, acute dilatation of the stomach muscles accompanied shock, and in the sub-acute conditions, profound myasthenia was present. From our experiments it may, therefore, be noted that the same toxin also produced muscle fatigue of the viscera."

The local fatigue of muscle tissue of the stomach wall, with accompanying myasthenia and dilatation, was also subjected to careful experimental research. First, by producing muscular fatigue by overstretching the muscles and limiting its blood-supply.[47]

EXPERIMENT No. 1.—"Dog; weight 18 kilograms, large black-and-white fox mongrel. Animal placed under anæsthetic and a bag and tube introduced into stomach and connected with a compressed air tank. The tension was raised to 60 mm. This was repeated several times, the air being allowed to escape completely each time. This was continued for an hour and three-quarters. The bag was distended with air and kept in one or two minutes, frequent rest periods being permitted.

"On opening the abdomen, the stomach was found dilated and very easily distended. Continuing the dilatation of the stomach with air after opening the abdomen, it was found that 50 mm. of air-pressure dilated the stomach to four times its usual size. The stomach was very flabby and soft and did not respond to any stimulant or cause the usual rhythmical contractions. The stomach was removed from the living animal and specimens taken from the body, cardia, and pyloric portions of the wall. These were placed in a fixation solution. The mucosa was previously removed from the muscle walls and placed in separate jars, the muscularis chopped up and the fatigue products extracted." This resulted in muscle autolysis.

"This muscle-cell necrosis was determined by the microscopic sections and staining methods."[47] "Examinations of the Muscle Fibre of the Stomach Walls: Specimens were taken from the cardiac and pyloric ends, and the body of the fatigued organ. These were immediately placed in fixing solution and placed beside specimens from normal organs. The two sets of specimens were treated identically, for comparison. The specimens were stained with methylene blue, eosin, hæmatoxylin, toluidin blue. The pylorus shows the most marked changes; there was congestion of the blood-vessels, these being markedly distended. Some stasis exists. The nuclei do not take the stain well, especially the methylene blue, as does the normal tissue. The cytoplasm appears to be less granular in type and fails to take stain. The hæmatoxylin stain does not show the marked difference in reaction as does the methylene blue."

"The mucous membrane was removed from the muscular walls for separate extraction and the latter minced and macerated for bouillon."[47] "Bouillon," made

from the muscle extract, "injected *intravenously, intraperitoneal,* or *into the muscle tissue,* invariably resulted in muscle fatigue and its associated symptoms."

EXPERIMENT No. 5.—"Introduced fatigue bouillon into the peritoneal cavity of a dog, with a needle, without opening the abdomen, 550 cc. of the fatigue bouillon being used. The animal showed intense thirst eighteen hours after the injection, but vomited water as soon as it was taken into the stomach. Twenty-two hours after the injection, the animal was given one pint of milk, which it vomited. The abdomen was opened twenty-seven hours after the injection. The stomach contained fluid, was dilated, and the walls were flabby. Movements so weak as to be scarcely discernible, and response to stimulation very weak." [47]

ANTITOXIN PRODUCED BY FURTHER SMALL INJECTIONS

Further evidence of the presence of the toxin which produced these phenomena was furnished by the production of specific antitoxins. On injection of small, repeated "doses" of the muscle extract into animals they produced "a greater or less degree of fatigue results when toxins were formed more rapidly than their respective antibodies. These antibodies soon form in excess, so that as soon as fatigue toxins are formed, the capacity of the cell is increased correspondingly, and the increased amount of energy that can be liberated without evidences of fatigue may be accounted for. Repeated small injections of fatigue bouillon may ultimately result in producing more or less immunity to fatigue." [47]

All the numerous experiments have shown that the interaction of the specific "shock toxin" with natural antitoxin always had the same results, irrespective of the method by which the "shock toxin" was produced. In order to counteract the toxic effect of "shock toxin" it is necessary to increase the antitoxin. The methods referred to above achieve this aim, namely, the injection of small, non-lethal doses of the "shock toxin."

The following investigation demonstrated that the application of high degrees of heat induced physical changes which had effects similar to those obtained by previous "vaccination with shock toxin." Heat applied within the splanchnic area also acted as an antitoxin. It mobilized and increased the natural antibodies when applied intragastrically.[30, 31] (*New York Med. Jour.,* Jan., 1906. Also *Louisville Med. Jour.,* 1897).

LIBERATION OF "SHOCK TOXIN" FROM THE SPLANCHNIC VISCERA

In 1901 (*Phila. Med. Jour.,* Mar. 30, 1901) it was demonstrated by the experimental and clinical data that tissue toxæmia caused death, particularly from "shock in abdominal operations." In 1902 [45]

it was shown that "in operations in the upper abdominal area there is a greater danger from shock than in operations on the lower abdominal area. Even traction on the stomach greatly increases the liability to shock, while exposure to air adds greatly to the danger. If death does not follow, still the toxins formed are detrimental to convalescence, and the future welfare of the patients."

VISCERAL CELL NECROSIS BY LIGATURE

It had been definitely shown by experiments [47] that "autolysis of muscle can occur during life, particularly in muscle in which the circulation has been stopped." General shock and death has been produced, first, by blocking off the circulation, by tying off the portal vein, which caused cell necrosis in liver;[17] second, experiments by tying off the pylorus with tight ligature constricting the vessels and tissue, which also results in death of the animals; whereas partial ligature of the pylorus did not result in death. Local ligature of the veins at lesser curvature of the stomach produced cell necrosis and erosions, but not to a sufficient extent to cause death.[17]

In experiments Nos. 2 and 3:[6] "Tying off the pylorus enough to produce stenosis but not complete" did not cause death. The more rapidly the autolysis occurred the more quickly the toxic effect was produced. It was a matter of the time required to liberate the toxic moiety. The "shock toxin" is found in all tissues and only awaits liberation from the cells. It is, as Bowlby remarks, "a race against time."

The following protocols are selected from the series of experiments on the abdominal viscera from 1897 [17] to 1914:[82] "Ligatured to produce obstruction at the upper and lower levels of the intestines. In this series of experiments 155 animals were used, including monkeys, rats, rabbits, and guinea-pigs. No bacteria seemed to enter the blood or lymph vessels. The higher the ligation the more quickly was the issue fatal. The ferments in the upper alimentary tract are more active than in the lower levels, hence more rapid autolysis occurred." This was evident in all of the experiments as stated in 1914 [82]–1917.[86]

"Tying off high and low loops produces death, especially in high loops, because of the rapid cell necrosis and disintegration by the ferments."

Animal	Ligature	Syndrome Shock	Death	Time of Examination (made under anæsthetic)	Remarks
No. 2.	Duodenum	4 hrs.	24 hrs.		Erosions, Mucosa } fluid
" 3.	Jejunum	5 "		24 hrs.	{ Hemorrhage, Peritoneal coat
" 4.	Jejunum (lower)	5 "	48 "		
" 5.	Ileum	8 "		24 "	Effusion of blood in coats
" 6.	"	7 "		24 "	Effusion of blood in coats
" 7.	"	9 "		24 "	Effusion of blood in coats
" 8.	"	5 "		24 "	
" 9.	Section tied (small and large intestines)	12 "		24 "	Hemorrhagic points near ligature
" 10.	5 loops at different levels	2 "		4 "	
" 11.	8 loops	1 "		3½ "	Shock syndrome
" 12.	Colon and ileum loops	5 "		24 "	

In the following series of experiments the loops are made at different levels and after four to six hours the abdomen was again opened and the material taken from the site of the ligature for biological study and microscopical examination. Microscopically, the entire coat, including the muscle coat, showed cell necrosis by nuclear and cytoplasm stain reactions.

"The repetition of this experiment many times over has led me to believe that after the tying off of the duodenum there are antibodies that split up the proteoses and kill the animals because of their strength and the power of the proteoses fragments that are formed as the result of splitting up by the ferments formed by the antibodies located in this region.

"The delay in fatal results was obtained by injecting muscle emulsion from the intestinal wall." [82, 86]

The submucous juice containing the necrosed cells diluted with normal salt solution forming 50 per cent. emulsion. Alcoholic extract was also made. All the extracts were fatal on intravenous injection either into the same animal or of the same species. Fresh, normal tissue emulsion was not so fatal on intravenous injection.

DOGS

Intestinal loop ligature and allowed to remain 3½ hours to 6 hours

Dog	Loops	Time	Intravenous Inj.	Death
No. 1.	Jejunum	3½ hrs.	5 cc.	3 minutes
" 2.	Upper ileum	5 "	1 cc.	2 hrs.
" 3.	Lower ileum	6 "	2 cc.	24 "
" 4.	Duodenal jejunum loops	3½ "	0.5 cc.	3 minutes
" 5.	Middle jejunum loops	4 "	1 cc.	2 hrs.
" 6.	Upper ileum	8 "	2 cc.	24 "
" 7.	Colon	8 "	3 cc.	24 "
" 8.	Colon	10 "	5 cc.	24 "

"The study of the cause for this increased toxicity of the 'shock toxin' of tissue necrosis in the higher levels showed that the contents of the bowel in the dosage used was not so toxic that the tissue extract from the higher level was more toxic than that from lower levels; that this was due to the action of the richer ferments which acted as cytolysin 'antibodies.' [82, 87]

"The active immunity or partial immunity gained by small sublethal doses previously injected into the animal indicates the nature of the specific poison or 'shock toxin.' The localized formation of antibodies in the Zona Transformans is apparently specific. This is shown in the following protocols:[82]

"*Method:* After cleaning the surfaces of the mucosa of the duodenum, the jejunum, and the upper part of the ileum of rabbits, it was scraped from the muscle wall. The mucosa was removed so that none of the glandular elements remained. The cellular substance and the fluid were then recovered.

"The blood serum from the femoral vein, mesenteric vein, the mucosa and the submucosa were now placed in separate capsules (frozen CO_2), and placed in vacuum chambers with H_2SO_4. They were kept in refrigeration and protected until completely evaporated. The residue of each was then weighed and comparative titres made against the broth culture of the homologous cultures secured from the intestines.

"The dried residue of serum and cell substance was made into a 2 per cent. suspension with 8 per cent. salt solution. Dilutions of 1/20, 1/50, 1/100, and 1/200 were then used."

One cc. of each of the above mixtures was injected intravenously into young rabbits. When anaphylaxis occurred within three minutes this was regarded as a positive reaction. "Slight convulsions and recovery, or death delayed from twenty-four hours to one week, were considered for this quantitative work, negative." [82, 87]

By intravenous injection of varying titres of the "shock toxin," a quantitative estimation of the toxin was obtained. Dilutions of 1/20, 1/50, 1/100, and 1/200 were used.

THE TRANSFER OF "SHOCK TOXIN"

In these experiments it was evident that the poison of damaged tissue passed into the blood and produced its effect upon the splanchnic area by direct contact with the toxin in the blood. This autotoxæmia was investigated in the following manner: [53]

"I injected the serum of animals in shock into healthy animals, and by increasing the dosage I found that animals so injected soon manifested the symptoms of shock. These experiments were repeated a sufficient number of times, and the results were constant in the disturbance of circulation, respiration, lowered temperature, resulting in collapse. Thirty animals were used, including guinea-pigs, rabbits, and dogs. The following experiment will illustrate:

"Two dogs; brothers; eleven months old.

"Dog No. 1.—The abdomen was opened and the viscera exposed to a cool draught of air; at the same time the viscera were frequently manipulated until profound shock was produced. Loss of reflexes, lowered blood-pressure, failing respiration, temperature reduced to 95.2° F., marked congestion of the splanchnic vessels, and marked anæmia of the periphery. Time, one hour and 55 minutes. The animal was then bled and the serum used to inject into dog No. 2. Injection of 5 cc. produced but little noticeable effect. When 50 cc. had been used, the animal showed marked fatigue. When 150 cc. was injected, the animal was in a state of collapse.

"A rabbit will sometimes go into convulsions and manifest all the evidences as if poisoned by snake poisoning. Small injections, frequently repeated, will etablish the phenomena of shock without convulsions.

"The conclusions are well shown that in shock there are tissue and blood changes that are produced, and when the serum or blood of animals in shock is injected into a healthy animal, it produces shock in the second animal. This corresponds to Morro's experiments on fatigue, in which fatigue produced in one animal by injection of blood into a healthy animal resulted in fatigue of the second animal." [53]

GENERAL TISSUE DAMAGE

General tissue damage must be distinguished from local tissue damage. As to the actual phenomena of shock, the conclusion was drawn in 1901 (*Phila. Med. Jour.,* Mar. 31, 1901, p. 622) that "experiments showed altered tissue cells and blood in shock, and, therefore, regarding shock as altered metabolism" was a logical conclusion. When general damage to the tissue cells was inflicted as distinguished from local injury as occurs in a wound, shock was produced in proportion to the degree of general tissue damage produced. The use of the anæsthetics, chloroform, ether, and alcohol, produced general tissue damage. As an example: The chemical injury of the anæsthetics used resulted in general cell necrosis with finally the formation of tissue poison. These tissue-toxins produced shock, as was demonstrated by the writer in 1903. The reader is referred to this article, with the protocols, entitled "Shock Produced by General Anæsthesia" (*J. A. M. A.,* May 2, 1903). "In studying shock from anæsthesia it is not only essential to consider the specific toxin of the anæsthetic used, but the resulting toxic bodies generated through the immediate or more remote influence of general anæsthesia." This work was on the "consideration of the anæsthetic as a cellular poison" and "the toxins that are evolved either from the direct effect of the anæsthetic or the disturbances of certain functions of the body." [49]

Conclusions: "The conclusions that can be drawn from the details of the experiments made on animals under chloroform or ether are that where shock is produced, it does not materially differ from the shock that results from trauma. The most constant pathologic factor is failure of circulation, and this is especially expressed in splanchnic congestion. The failure of temperature and respiration has been considered to be the result of vascular failure, with the corresponding fall of blood-pressure." [49]

It was demonstrated in this as in other experiments that the shock phenomena were the effects of the tissue-toxins. "Aglutinins, precipitins and hæmolysins were demonstrated by the effects of the tissue-toxins. Blood coagulation was prompt." The blood corpuscles became thereby contiguous in the capillaries. All this accounted for the splanchnic stasis. The secondary symptoms, the fall in blood-pressure

and temperature, were not always synchronous. The temperature range gave a most delicate index.

"It will be seen, however, by referring to the protocols 13 and 15, that the temperature fell several degrees after the injection of the serum, while the blood-pressure did not always show a corresponding fall." [49]

The production of general cell necrosis with resulting "shock toxin" may be illustrated by a few of the following experiments taken from a long list of protocols:[49]

EXPERIMENT No. 3.—"Dog; curly, black; weight, 16.2 kg. Anæsthetic, chloroform. Five hours. Temperature at the beginning was 38.3° C., by rectum. Blood-pressure, 120. In one hour. temperature, 37.2°. At the end of four hours temperature was 35°. Anæsthetic removed. Animal shows no sign of awakening. Four hours and thirty minutes after, temperature, 37°. Chloroform was then used. Five hours, temperature, 36°. The animal was placed in a warm location. Twenty-four hours afterward temperature was 36.5°. Refused to eat; marked depression; blood-pressure, 90. The animal was bled; recovered 550 cc. of the blood. Coagulation prompt.

EXPERIMENT No. 4.—Dog, mongrel bull terrier. Ether. Weight, 18.5 kg. Blood-pressure, 150. Temperature, 38.6°, rectum. At the end of two hours the blood-pressure was 95 to 105. Temperature, 37. Four hours, blood-pressure, 78; temperature 36.1. Animal placed in warm place. Twelve hours after, rectal temperature, 36.5°; blood-pressure, 90 to 95. Animal bled; recovered 380 cc. Coagulation prompt.

EXPERIMENT No. 14.—Dog, mongrel pointer; weight, 17 kg.; 4 P.M., blood-pressure, 140 to 145. Kymographic tracings. Anæsthetic, chloroform. Injected serum from dog, removed twenty-four hours after anæsthesia, which had been continued for six hours. Twenty minutes after this injected 25 cc. of serum. 4.30 P.M., 50 cc. of serum injected. Blood-pressure, 110; 25 cc. injected; blood-pressure, 80. At 6.05 P.M.. 30 cc. injected; pressure, 57 to 60. Chloroform anæsthetic changed to ether; blood-pressure rose 20 mm. Again dropped to 50. Anæsthetic was withdrawn, aseptic dressings applied, and dog put in a warm place. Result, death in six hours.

EXPERIMENT No. 17.—Small black-and-tan under chloroform. Blood-pressure, 130. Serum used from a dog which had been under anæsthetic five hours, and bled the following day; 25 cc. of serum injected. Fifteen minutes, pressure fell to 115; twenty minutes, 110; thirty minutes, 95; in one hour, 25 cc. serum injected. Blood-pressure, 15 minutes, following the last injection, 65 to 70. Anæsthetic removed. Animal died the following day.

EXPERIMENT No. 21.—Fox terrier; female. Temperature, 39.4. Injection of serum taken from dog twelve hours after two hours of anæsthesia; 16 cc. injected, with a fall of blood-pressure, followed by a chill as soon as the anæsthetic was removed. At the end of one hour, temperature was 37.3°; one and three-quarter hours afterward, 37.2°. Animal placed near a warm room, and continued in a condition of shock, and died six hours afterward.

A French observer, Munch, in 1903 ("Experience sur le Choc," *La Sémaine Médicale,* May 27, 1903), made a careful study of the writer's work on tissue-toxins as the cause of shock and related phenomena. He also made other observations corroborating the writer's findings. This included the toxins of cell necrosis, the diffusion of these in the blood, the agglutination and the resulting splanchnic stasis comprising the shock phenomena. This review has also been referred to by Jeanneney.

The fact that the toxin was present in the circulation was proven by injecting blood taken from a shocked animal into a normal one. This led to the immediate appearance of typical shock symptoms ending in death [49] (Pan-Amer. Cong., Havana, Cuba, 1901).

DIFFUSION OF THE SHOCK TOXIN

In order to demonstrate that "autolysates" have the property of diffusing through the body, sterile fetal animals were allowed to autolyze in an incubator The serum resulting from cell autolysis collected in the receptacle. It may be compared to the serum of individuals in whom cell autolysis has occurred during life. Some of this fluid was passed through a Pasteur filter and when injected into animals, it caused death in shock.[72-74, 78]

The diffusion of polypeptides cannot be traced by the eye. For this reason the mechanism of colloidal diffusion through the body was studied by substituting visible bacteria and other colloids.[72-78,82,86,87]

There is no necessity to present here a detailed account of these experiments, for we may refer to the exhaustive review of my work, published by Jeanneney in 1919.* Among the points stated we find the conclusion: "Turck, therefore, has verified the toxicity of dead cells. He has affirmed the diffusion of these toxins by comparison with *coli bacilli,* which can be revealed, while one cannot follow the traces of polypeptides."

In the experiments (1890-1901) hitherto recorded, cell autolysis was produced through inflicting local injury by mechanical, physical, and chemical means. The local method included wounding and crushing of tissue and ligature of blood-vessels. Similar results were

* Jeanneney, G.: "Theories Pathogeniques du Choc Traumatique," *Progrés Méd.,* Sept. 10, 1921.

produced by application of extremes of heat and cold while, finally, the list of chemical agents includes alcohol, ether, chloroform, tannic acid, and mustard oil.

SYSTEMIC AUTOLYSIS

The next important step was the observation that *general autolysis* may be induced by biological methods. As an example of the autolysis from starvation we have the toxæmia of starvation; though the mechanism by which this is effected is obscure, it may be said to depend on the "law of self-preservation." Any form of partial or total inanition in our experiments produced similar toxic effects (1906-1907). By a method of *fractional starvation* the *autolysis* was induced the same as in total starvation. The effect of this method was often more active in *producing* toxic manifestations.

This principle was discussed and conclusions drawn from a long series of experiments in systemic autolysis, as follows:

"We might look upon every organism as a battle-field on which a continuous struggle between life and death takes place. The sum of the chemical changes which make up this battle is called metabolism.

"In the latter we have a continuous building up and breaking down of tissue and food, which two processes correspond to what we call synthesis and catalysis. Auto-cytolysis or self-destruction of the cell, which process takes place under normal circumstances, is counterpoised by anticatalytic substances" (1907).

"If food is supplied to a normal organism in the ordinary way it passed into the stomach, where it is transformed into a chemical state in which it can easily be absorbed from the intestine and supplied to the different parts of the body; if we discontinue this supply of provisions, as in starvation, the organism will be compelled to make up for the deficiency in food supplied by the stomach, and will by a process of auto-digestion make use of the food which is stored up in certain parts of the body, in the form of muscular tissue—flesh. This may result in auto-intoxication, as these products of auto-digestion of the tissues do not first pass through the liver, which occurs during the ordinary normal process of digestion and resorption in the alimentary tract." [66]

DEGENERATION THROUGH QUIESCENCE

A number of investigations were undertaken in order to induce degenerative changes in controlled experiments.

One line of research was based on the natural occurrence of profound changes in the lower animals resulting from the adoption of a parasitic mode of existence. This is well illustrated by sacculinæ. While young, they are active and free swimming, much like a young prawn or crab. Later, however, they attach themselves to the abdomen of a crab and soon degenerate into a tumor-like sac. In all such parasitic animals degeneration rapidly supervenes as soon as they become sessile and inactive. Another instance is the tunicate or sea-squirt. When it attaches itself to a stone or shell, the active little fish degenerates into a "mere rooted bag with a double neck." The same process occurs in barnacles.

The biological mechanism of this degeneration was investigated in a series of animal experiments in 1901 and 1906.[41, 58]

EXPERIMENT

"Ninety-six guinea-pigs and thirty-six rabbits were used in these experiments, which were continued for nine months. The animals were confined in small, sterilized cages. Blood determinations were made before and during the course of the experiments. As soon as an animal showed any signs of infection it was removed.

"During the first three or four months the animals gained in weight as a result of deficient exercise and oxidation, but later became emaciated. At the end of nine months all the animals had died. Of the ninety-six guinea-pigs only six survived. Peptic ulcers and other signs of degeneration were found."

PARTIAL STARVATION

Another method of inducing general autolysis consists in interfering with the normal processes of digestion, absorption, and assimilation. This method was utilized in experiments carried out in 1906.[58]

PARTIAL AND FRACTIONAL STARVATION

"*Feeding Experiments in Mice and Rats.*—Bouillon cultures of *B. coli* were added to raw beef in one experiment, and in a second experiment to the extract of beef. In a third experiment they received

extract-free beef. As controls a second series of rats were given raw beef and extract-free beef respectively. The experiment was continued for one month. At the end of this time the rats fed on extractives and extractives containing *B. coli* died. The other rats of the series were killed at the same time for comparison. The post-mortem examination was negative so far as microscopic appearances were concerned in all except the extract-fed rats. These showed marked decrease in fat. Their organs, especially the livers, were pale in color. In the group of animals on full ration but fed in addition extract of beef, detailed microscopic examination of the effects of partial starvation and induced autolysis with general toxæmia and degeneration may be found by consulting the literature (1906–1908). Feeding animals with heated fat added to the ordinary ration."

A number of monkeys received food containing heated fats.[82-, 87] This sufficiently interfered with normal digestion, absorption and metabolism, to induce profound tissue autolysis with the usual fatal result. The histolysis and resulting toxæmia resulted in venous stasis and caused death in a few weeks in monkeys The protocols on six monkeys are as follows:

Monkey	No. 1	died	in	61	days
"	No. 2	"	"	57	"
"	No. 3	"	"	42	"
"	No. 4	"	"	31	"
"	No. 5	"	"	28	"
"	No. 6	"	"	38	"

In a review of the early literature (1897-1900) the clinical study was made in the living subject during operations, with observations on the open abdomen (Study of Living Pathology in the Human. 1897–1900).

CLINICAL APPLICATION

The experiments recorded so far give an outline of the research which formed the basis for certain fundamental biological laws. The question now arises, what is the clinical significance and to what extent does the clinical application of the findings open new therapeutic possibilities? These problems have formed the basis of many reports and discussions dealing with clinical methods and case reports. In this connection, we may refer to a symposium on post-operative complications entitled "Experimental Shock." [77]

Doctor Seelig in the symposium also showed that the cause of shock did not depend on nervous phenomena. Doctor Pike * reported experimental researches establishing the fact that a definite amount of time had to elapse before profound changes occurred in nerves and nerve centres, as evidenced by vacuolation. Even actual death of a few cells within a nerve centre does not necessarily indicate that a total loss of function had occurred. Studies of the central nervous system have shown that † "a very considerable residual blood-pressure was observed long after the brain and medulla oblongata had ceased to function." "After removal of the spinal cord and the consequent elimination of any reflex or automatic effect on the skeletal muscles, there is still a significant blood-pressure due to some mechanism outside the spinal cord and presumably more or less distinct from the heart." ‡

ANAPHYLACTIC SHOCK

Injection of Animals with Culture of B. Coli

In all the preceding experimental work it was demonstrated that local and systemic autolysis resulted in the liberation of the "shock toxin," which is autochthonous. No "foreign agent" directly produced these effects. They were "induced" and not "produced."

It was found in our experiments of 1904–1906 that when a foreign colloid was injected into an animal, after ten days a link or bond seemed to be established between the foreign colloid and the animal's own tissues, so that subsequent injection of the same colloid resulted in a contact shock reaction on account of the mobilization of autochthonous cytost.

These findings were made during some experiments on the etiology of peptic ulcers. A preliminary report on these experiments was first presented in a symposium on "Gastric Ulcer." § The phenomenon we now term "anaphylaxis" was first studied in some research work

* Gomez and Pike; *J. Exp. Med.*, 1909, vol. xi, 262.

† Pike; *Quart. J. Physiol.*, vol. vii, 2 pp. 1-2.

‡ Pike; *Quart. J. Exp. Physiol.*, vol. vii, 5, Sept., 1913, p. 13.

§ Presented before the International Med. Cong., Lisbon, 1906. The preliminary report on these experiments was first presented in the symposium on Gastric Ulcer before the Amer. Gastro-Ent. Assn., 1904, and withheld from publication for more careful revision and research. Presented before the joint meeting of the Chicago Pathological Soc. and Chicago Med. Soc., March 21, 1906.

on the production of ulcer of the stomach by feeding animals with cultures of *B. coli* in meat bouillon. Animals were also injected with both living and dead cultures of *B. coli.*

FIRST SERIES OF EXPERIMENTS

"Injection of cultures of *B. coli* into the jugular vein at intervals of two to five days."

No acute reaction was manifested although "the injections were continued." [58]

In the second series of "Injecting Experiments" the intervals of the intravenous injections of the *B. coli* were made *ten days apart* instead of every two days. During this period of ten days after the first injection, the colloidal particles injected acquired the specific constituent or charges from the animals that were injected. Therefore, on repeating the injection ten days later, shock reaction promptly followed the same as if the animal had been injected with homologous tissue.

Results, as stated in 1906: "The reaction of the injection at first was anorexia and vomiting with general lassitude for a day or two. After an *interval of ten days,* the reaction to inoculation *would be considerable,* but would be much less pronounced if the inoculation was then repeated in a day or two. Later, after three months of such inoculations, no reaction could be obtained even though large numbers of bacteria were introduced. *B. coli* was agglutinated by the dog's serum in dilution 1/5000 ten days after the first inoculation." This high degree of agglutination indicated that the colloid injected had acquired certain specific changes which caused the reaction on the second injection.

This reaction, which I had clearly demonstrated in 1904, was also produced by feeding experiments, and this phenomenon was studied and named by Richet afterwards "anaphylaxis" and "anti-anaphylaxis." This expression, "anaphylaxis," is a misnomer and with the various theories that were added, produced much unnecessary confusion. The inert colloids injected do not produce the shock reaction, but they gather the specific particles contained in the host, which, by adsorption of the autochthonous "tissue particles," produce shock. This is the same, therefore, as shock produced directly from the autochthonous "shock toxin." These experiments gave additional

evidence of the tissue-toxic origin of shock and many related conditions. I had explained these reactions (1906) as "a systemic condition, and of an induced cellular change." This "induced cellular change," like an inductive electric reaction, was also obtained by feeding animals.

Animals were fed with extracts of beef and *B. coli* (1908) in massive doses followed by a rest period without the feeding. On resumption of the feeding of the same massive doses, acute shock and death followed.

The experiments were as follows (*Journal Med. Research,* 1908, p. 369): "First, feeding for two months, gradually increasing; second, stopping the feeding for two months; third, the resumption of the maximum feeding, one thousand cubic centimetres bouillon, *B. coli.* The results were violent reactions; two cases, psychosis followed by death, and two by diarrhœa and bloody flux followed by death." The phenomena were as given in protocols 1, 3, and 4, and may be compared with the intravenous injection, producing similar shock.

ANTIANAPHYLAXIS

By small injections more frequently repeated antianaphylaxis occurred, but this is due to the antibodies in the animal's own tissue, produced to combat its own tissue toxin.

The incubation period for the passing of the specific charges from within the animal tissue to the foreign colloid injected was found by these experiments (above reported) in 1904 and 1906 to be about ten days. It seemed then most important to determine whether the "incubation" time could be shortened outside of the animal by bringing the foreign colloid in contact with the animal's cellular tissue, or the extract of the tissue. For this reason the foreign colloid was placed in an incubator together with the extract specific to the animal. The foreign colloid then assumed the specific properties of the animal tisue by simple contact for a short period of, at most, half an hour. It required but very small non-lethal doses of the animal's tissue to "leaven" the whole foreign mass of colloid, so that the large surface area was thereby rendered specific to the animal. It was found unnecessary for the colloid to be of animal origin. Any indifferent or neutral colloid having similar surface properties produced the same results. These experiments seemed to show that any

foreign agent injected into an animal which may cause a shock reaction does so by first mobilizing the specific "charges" of the tissues of the animal injected.

Five cubic centimetres (5 cc.) of *B. coli* was intravenously injected into rabbits with negative results. Cell substance of rabbits, mucous membrane and submucosa were made up 2 per cent. of the dried residue in 8 per cent. salt solution. Dilutions were made in 1/20, 1/50, 1/100, 1/200, all of which were in such low concentration that no anaphylactic shock occurred. On adding these low concentrations (high dilutions) to the 5 cc. of *B. coli,* the specific charges of the homologous rabbit tissue charged the "surface" of the colloid mixture of *B. coli.*

It was found that serum from the mesenteric vessels of homologous animal in this high dilution gave some anaphylactic shock charges to the colloid mixture, while serum obtained from peripheral vessels did not show the reaction in these dilutions.

Table of Transfer of Homologous "Charges" in Vitro

Dilutions	Mucosa and Submucosa	Submucosa Zona Transformans	Mesenteric Veins	Femoral Veins
1/20	+	+	+	—
1/50	+	+	+	—
1/100	+	+	—	—
1/200	+	+	—	—

Controls.—In controls there was no anaphylaxis even when double quantities of the mucous membrane sera of *B. coli* cultures were given.

On injecting submucous substance (amboceptor) without the addition of culture, no anaphylaxis occurred.

CYTOST

The *broad* application of the one thing—the *principle* of cytost-anticytost reaction was further developed by additional experiments induced by the war (1918).

The possibility of transferring the specific charges of "cytost" to foreign colloids *in vitro* furnished a means of demonstrating experimentally the mechanism of shock, anaphylaxis, allergy, and allied phenomena and explains why the intravenous injection of any colloid may cause the same results as though it were homologous tissue.

Actually the reactions are due to the mobilization of autochthonous cytost by foreign colloid.

The following table refers to data representing groups of experiments. It is shown that heterogeneous cytost is without effect when injected intravenously or intraspinally, unless it has acquired the "specific charge" by incubation with homologous cytost.

Animal used	Antigen injected	Amount injected	Method of injection	Results
Cat	Cat cytost, 120 mg.			Complete
	Ster. water, 1 cc.	¼ cc.	Lumbar punc.	paralysis
"	Rat cytost			
	prep. as above	¼ cc	" "	Negative
"	Rat cytost, 120 mg.			
	Cat cytost, 12 mg.			Shock
	Ster. water, 1 cc.	¼ cc	" "	Incoördination
"	Rat cytost			
	Cat cytost			
	Anticytost	¼ cc	" "	Negative
"	Cat cytost	1 cc.	Intravenously	Death 30 sec. to 3 min.
"	Lion cytost	1 cc.	"	Negative
"	Lion cytost, 120 mg.			
	Cat cytost, 12 mg.	1 cc.	"	Anaph. shock
"	Lion cytost			
	Cat cytost			
	Anticytost	1 cc.	"	Negative

IMMUNITY

Natural Immunity.[87]—In both acute and chronic disease natural immunity always limits the degree of the reaction. The animals which did not perish in the acute stage were saved by virtue of the degree of natural immunity acting at the time. This may be operative in preventing acute death, yet allow the chronic reaction to continue. "The venous stasis and colloidal diffusion as etiological factors" produce (1917) (*Med. Rec.*, June 16, 1917, p. 1028), as was expressed: "The local changes that are seen to take place consist of an autolysis of the tissue cells combined with venous stasis, as shown by marked dilatation of the venules and contraction of the arteries. The appearance of the tissues indicates what we understand by the generic term 'acidosis and asphyxia of the cells'" (*Id.*, p. 1029). "As we study the problem of autolysis in this connection we are confronted with

the question of just what normal autolysis is, and not only with the problem why the bacteria are destroyed, but also why they are not destroyed."

It is this natural immunity which I have endeavored to develop in all my research work of the past thirty years. It has shown that the application of heat at high temperatures increases the natural immunity against the tissue-toxins.

TREATMENT

The *treatment* of these various *manifestations,* or diseases, has been presented with experimental and clinical data. Reference to the more recent literature (1918–1921) will show the methods of treatment in detail.

It may be of interest here to show that "natural immunity" can be increased and that a definite and adequate method of immunization has been established.

Preventive or Prophylactic.—The prevention of disease is achieved by increasing resistance. All exposed to the danger of disease we therefore fortify by attempting to increase their natural resistance. The Spartan mother endeavored to make her young hardy and thus increased their natural resistance. In the modern treatment of tuberculosis the whole aim of prevention and cure consists in the attempt to increase resistance. The means of accomplishing this end has thus far been purely empirical—sunlight, fresh air, rest, and appropriate exercise—physico-mechanical therapeutics and dietetics (little more than empirical methods).

To learn to what extent these methods were being taught and used I sent out a questionnaire in 1901 entitled "Necessity of a Practical Knowledge of Dietetics, Hydrotherapy and Physico-mechanical Therapeutics." [40] The replies furnished a lamentable disclosure that but little was actually being taught on these subjects. One reply stated that "for some unknown reason they have been neglected by our schools the world over." [40]

In the course of my research work I have shown that shock is not due to a reaction on the nervous system, but to a toxin. The experience derived from the war has shown that the means of counteracting shock were *débridement,* heat and stimulation (Lemaitre), and thus confirms my contentions.

Coming to the question of immunity, we find that physical mechanisms, including hydrotherapy, thermal and electrical methods, up to the time of the war, received comparatively scant attention. The mechanics of surgery, the bogey of "focal infection," and the psychoneurosis concept displaced all other ideas. The war changed this. Soldiers in *camps* gained increased immunity. Heat was used to prevent and cure shock. Early *débridement* and primary suture removed disintegrated tissue, which caused tissue-toxin and shock. Finally an antitoxin was developed as a preventive and cure for shock, but which has been effective in many other conditions.

What was discovered in the war as the cause and cure of shock is universally agreed upon and has been adopted by all. The conclusion of McLeod, in America, and of Jeanneney, in Bordeaux, is that this is the *principle* which my work has set forth in over one hundred publications covering the period from 1893 to 1914. Before the war this had been scientifically established. This principle has now been verified by clinical application, as established in Europe and this country during and since the war.

In the *Military Surgeon* (Jan., 1921) Major Lemaitre has given a detailed report of the application of tissue toxæmia and shock. He says, "The injury kills the tissue" (p. 19); "mortification of the muscle tested by color changes, lack of bleeding, lack of fibrillary contraction when pinched with forceps" (p. 20). "By *débridement* and primary suture we trust to the vital power of the patient, being careful not to interfere with the process of auto-immunization of the patient" (p. 25).

This is far-reaching in biology, as it further establishes the specific character of the cause in all conditions of shock and in *all* normal and abnormal conditions.

Another great advance was made in the study of the nature of natural resistance or natural immunity. It was early found that small, repeated injections of the cytost caused natural immunity to be increased (1903, 1906, 1908).

It was also found that heat at a high temperature, especially when applied within the splanchnic area, increased natural immunity[47] (*Muscle Fatigue*).

These methods of producing active immunity naturally led to methods of producing passive immunity.

When anaphylaxis occurs it is not due to the antigen injected, but to the "taking on" of the changes from the host on the introduction of any substance whatsoever—salt, colloids, or non-colloids. My experiments have all shown this, as may be seen by referring to the Bouillon protocol, the *B. coli,* negative and tissue injection protocols, etc.

It is this taking on of changes by the material injected which produces the homologous cytost. The word "sensitization" is a wrong term; the process simply brings the animal's free homologous cytost into contact with the host, where it produces a reaction.

SUMMARY AND CONCLUSIONS FROM THE REVIEW OF THE PRE-WAR EXPERIMENTAL AND CLINCAL RESEARCH

Nature and Pathology of Shock.—The etiology of shock is found to be the "shock poison." The first change is the cellular and cellular fluid reaction, which shows agglutination, precipitation, and coagulation. These agglutination, precipitation, and coagulation studies were made in 1902 and 1903.[49, 50, 51] The anæmia of the tissue causes further autolysis in cases of delayed death—a secondary toxæmia from the break-down due to the anæmia.

The Transmissibility of "Shock Toxin" from One Animal to Another.—This was demonstrated by the injection of "shock toxin" (1900, 1902).

Production of Shock by Anæsthesia.—This was demonstrated in 1903.

The Use of Colloids (Bacterial) Fetal Tissue (1909, 1910). (See author's literature, 1914–1917.)

This review of the clinical and experimental research of twenty years, up to the beginning of the war, does not represent many unrelated things; *it means only one thing.* That thing is now established beyond the power of institutional and academic forces to prejudice the mind by "philosophical preconceptions."

It required the war to shake off the incubus of the "former unsupported speculations and prejudices." The review of this subject by Professor McLeod, by Hartman and Jeanneney in France, and by many others, gives credit to this work as being the first to establish this principle. It has been proven by practical application on an unprecedented scale, which has yielded statistics so comprehensive as

to preclude error. Others have made reference to this principle, which may be found in Chinese philosophy, but this review of ours shows a purposeful and continuous research on one subject consistently and persistently prosecuted. Jeanneney * reviews it as follows, after referring to work of others and then to ours, and then to the bibliography of the pre-war research: "These theories certainly have never been exposed before the war in any connected form, but one finds them scattered as simple post-experimental reflections or indications in about forty works of most diverse titles (as shown by the bibliography). One may say that the war with its experience and the research it caused has permitted Turck to realize in one synthesis applied to shock (series of articles) his life-work."

The vastness of the medical problems of the war has forced all medical authorities the world over to bring forward their biological theories as well as their clinical methods and practices and have them subjected to the grim test of reality. As a result, many an antiquated conception had to be abandoned. And no medical error has had more tragical results than treatment based on the psychoneurogenic theory of shock. However, the end of the war found medical authorities practically united in the conclusion that acute shock, as well as the resulting chronic affections, are the result, not of nerve changes, but of tissue-poisoning.

Major Lemaitre † stated that removal of the cause, *i.e.*, excision of damaged tissue, is the only effective mode of treatment. A temporary return to faulty pre-war methods with antiseptics led to the prompt reappearance of the 75 per cent. mortality which had been the despair of military surgeons during the earlier stages of the war.

It is, therefore, justifiable to consider the modern and only successful treatment of shock a practical clinical application of the principles which I had established by the clinical and experimental investigations undertaken in the course of the twenty years from 1894 to 1914.

The results obtained by my earlier experiments were amplified by numerous other researches, carried out in the course of the last thirty years. There is no need to give further details of my work in the present communication, for I have published a large number

* "Choc Traumatique," *Progres Med.*, 37, Sept. 3, 1921.

† *The Military Surgeon*, vol. xlviii, No. 1, 1921.

of papers and addresses both in this country and in France, England, Germany, and Austria. I may state, however, that continued researches carried on during the war and up to the present date have all served to corroborate and further crystallize my previous findings. For experimental reports and clinical data, I refer to my bibliography.[82-98]

In conclusion, I wish to emphasize once more that the elucidation of the problems of traumatic and operative shock is merely a special application of certain biological laws, which have been established through my researches. The general import of these laws for every branch of the science of biology cannot be fully measured at present, for every new investigation appears to open wider fields. However, the fundamental significance of the facts has been clearly demonstrated.

From the medical point of view, the outstanding feature is the proof that the increased blood viscosity, which develops during shock and ends in stasis and death, is a process underlying a large number of pathological reactions, classified under the terms of various diseases in clinical practice. While the acutest form of reaction is presented by shock, a similar, though more gradual, process is found in pneumonia. Chronic forms of tissue-poisoning lead to the "metabolic diseases," the chief among which are nephritis, hepatitis, pregnancy toxæmia, arterial sclerosis, arthritis, neuritis, peptic ulceration, and, finally, that vague group of cases characterized by fatigue, faulty metabolism, and a large number of miscellaneous symptoms. Small wonder that diagnosis and classification have offered unsurmountable obstacles in these cases, and that all varieties of treatment, whether of medical or surgical nature, have failed to cure; for attention has been centred on symptoms, while the actual etiologic factor, the lack of immunity to tissue break-down, has remained unrecognized.

I have previously published case reports, which demonstrated the gratifying results obtained by inducing immunity in such affections. The usual treatment is a combination of the production of active and passive immunity. The latter process is carried out by means of the serum of horses immunized against autolyzed human tissue.

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FEEBLE-MINDED AND BACKWARD CHILDREN

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In Europe, in the seventeenth century, there flourished a tribe or fellowship of wanderers, called the Comprachicos, who practiced with diabolical cunning a strange art. The word is a compound Spanish term meaning child-buyers, though the buying of children was not the distinguishing feature of this tribe, for bartering in human lives has been an approved custom of all races. It was the sinister ingenuities practiced upon its chattels that made the fellowship unique and that finally led to its dissolution by Imperial edict in the early part of William and Mary's reign.

The Comprachicos bought children as a manufacturer buys raw material; as a cabinet-maker buys rare woods—to work over into a form which may be profitably sold. The bizarre, the grotesque and the ridiculous has always commanded its price, sometimes a fabulous one. The ancients defied their monstrosities; savage tribes invest them with supernatural attributes; jesters, clowns and mountebanks, high in Court favor, have moulded the destinies of nations. The incongruity of a monkey dinner and theatre party adds zest to the life of Newport—a plagiarism from the time of Charles the First when the Duchess of Cleveland had a marmosset for a page and Baroness of Dudley was served with tea by a baboon—and so strong is the appeal of the "custard-pie comedy," that its leading exponents command the incomes of Captains of industry.

It was this morbid quality in human nature that the Comprachicos capitalized, and their wares found a ready sale among the wealthy and the great. Like other craftsmen of an earlier period they possessed trade secrets and tricks which, fortunately, are now lost arts. A child came into their hands, normal in body and in mind, he left them "a sort of fantastic stunted thing, ridiculous and wonderful" and awful. They would touch up a little being with such skill that its father could not have known it.

Sometimes the body was altered, sometimes the face; working on human flesh and bone as the Japanese work on trees and shrubs.

This is but an illustration of man's tendency to mar natural perfection for his pleasure or profit. But Nature herself does not always achieve perfection, for when the hand of the Potter shakes the results sometimes resemble those obtained by the arts of the Comprachicos, serving irrevocably to set the unfortunate victims apart from their normal fellows.

It is thus with the feeble-minded, who like the poor, are always with us. A perpetual problem, the attempts at solution have varied with the epochs of history. The Spartans and other nations relieved themselves of the burden by exposure and even violence. In the early Christian era, leaders of the early Church plead the cause of these unfortunates, and they were commended as objects of mercy by Confucius, and Zoroaster and Mohammed. The Koran enjoins charity for the feeble-minded upon all true believers "maintain them, clothe them and speak kindly unto them." For the most part, however, the lot of the feeble-minded has been one of persecution, derision and humiliation. In the Renaissance both Luther and Calvin denounced imbeciles as "filled with Satan." Proper consideration for the feeble-minded came about more or less directly and synchronously with the evolution of modern educational methods initiated by Jean Jacques Rousseau and Pestalozzi. At this time Jacob Rodrigues Pereire, who has contributed much not only to corrective pedagogy, but to general educational science as well, was the head of a school for the deaf in Paris, a near neighbor and friend of Rousseau. The influence of each upon the other is apparent, as is the influence of both upon Jean Marc Gaspard Itard, physician to an institution for the deaf in Paris and the first person to undertake the systematic training of idiots. It was Itard's glorious failure with a wild boy, the so-called "savage of Aveyron" which aroused the interest of Edward Sequin, a French physician, who founded a school for the education of idiots in Paris in 1837, the first one ever founded and successfully conducted for this definite purpose in all the world.

The "Sauvage d' Aveyron," a boy about eleven years of age, was found by huntsmen in the woods of Caune in the Department of

Aveyron, wandering about in search of food in the form of nuts and acorns. He was more like an animal than a human being, expressing his wants by inarticulate cries, fighting with teeth and nails, and often walking about on all fours. Itard, believing that the boy's lack of mental development was due to neglect, undertook his education. Failing to meet with the success he anticipated, Itard finally gave up his undertaking in despair, though the French Academy, seeing better than he the success of his teaching, commended his efforts with unstinted praise. Sequin, more practical than his preceptor, Itard, realizing the extent and significance of the "wild boy's" progress and the practical application of Itard's methods in the education of the feeble-minded, improved and amplified them into a definite system of physiological education, which forms the foundation for practically all of the effective work with the feeble-minded to-day and, with certain modifications and elaborations, for the Montessori system for the education of normal children. There is no doubt but that Sequin's enthusiasm, together with the definite results which he achieved, was responsible for arousing an intelligent constructive interest in the care and training of the feeble-minded, which has changed the public attitude toward them from one of barbaric neglect and persecution to one of helpful commiseration.

Some one, Mr. Choate, I believe, has said "the difficulty about the problem of the feeble-minded is that there are so many of us." Statistics endeavoring to show the proportion of feeble-minded individuals in the general population are of comparatively little value, for reasons to be touched upon later, but I believe that it may be safely said that there is at least one definitely feeble-minded individual for every six hundred of the general population, though Kuhlmann and others place the number at one to two hundred as a conservative estimate. The incidence in selected groups, as delinquents, juvenile and adult, inmates of asylums, institutions, etc., is considerably greater.

It has long been the custom, in this country, to employ the term "Feeble-minded," to designate generically all degrees and types of mental defect, from the profound idiot up to the individual but little below the normal in intelligence. This designation has its advantages as it still admits of all necessary differentiation into various

sub-classifications. The term "idiot" is often wrongfully used in the same sense, although the idiot properly is the lowest grade of the feeble-minded, incapable of intelligent communication, able to give little or no care to his person, ungainly in his movements if he move at all, living for the most part a merely vegetative existence.

The term "Feeble-minded" has also been used in this country, as it has in England, to designate the highest grade of Amentia (feeble-mindedness). Thus, the British Royal Commission of 1904 defines a feeble-minded person as:

> One who is capable of earning a living under favorable circumstances, but is incapable, from mental defect existing from birth, or from an early age, (a) of competing on equal terms with his normal fellows; or, (b) of managing himself and his affairs with ordinary prudence.

An imbecile as:

> One who, by reason of mental defect existing from birth, or from an early age, is incapable of earning his own living, but is capable of guarding himself against common physical dangers.

An idiot as:

> A person so deeply defective in mind from birth, or from an early age, that he is unable to guard himself against common physical dangers.

Tregold defines "Amentia," which term he uses to describe the condition characteristic of the whole class (feeble-minded) as "a state of mental defect from birth, or from an early age, due to incomplete cerebral development, in consequence of which the person affected is unable to perform his duties as a member of society in the position of life to which he is born."

In 1909, the American Association for the Study of the Feeble-minded, as the result of the report of a committee upon the subject adopted a tentative classification based upon the use of the Binet Tests, and suggested the term "moron" for the highest group.

While this scheme of classification as far as it is based upon problematical mental age may be open to some objection, and in fact was left open for further investigation and discussion, yet the division of the feeble-minded into three classes of, moron, imbecile and idiot, further divided into high grade, middle grade and low grade, is an excellent one, admitting as it does of further type description depending upon physiologic and pathologic data.

In the consideration of feeble-mindedness there are certain funda-

mental conceptions regarding which there is a very general agreement. These have been most ably and concisely stated by Dr. Rogers, as follows: "The *first* has reference to the general but constant characteristic of the ensemble of infirmities that we now speak of as feeble-mindedness, *viz.*, that it is *mental incapacity* from *arrested development* more or less complete, whether the cause is (1) lack of potency in the germ plasm from inheritance; (2) interruption of biologic evolution *in utero* from (a) toxic interference or (b) deficient nutrition, or (3) an arrest of development, more or less extensive, in the cerebro-spinal axis after birth from (a) inflammatory processes;

	Descriptive terms.	On scale of 10.	Mental age as determined by Binet tests.
A.	NORMAL:		
B.	FEEBLE-MINDED:		
Morons	High grade	9	8–12
	Middle grade	8	
	Low grade	7	
Imbeciles	High grade	6	3–7
	Middle grade	5	
	Low grade	4	
Idiots	High grade	3	0–2
	Middle grade	2	
	Low grade	1	

(b) toxic influence; or (c) deficient nutrition. The mental incapacity varies in different individuals from completeness, so that the existence is vegetative only, to merely a lack of coördination between the affective intellectual and volitional faculties, so that the individual is disqualified from harmonious social relations."

Thus the causes resulting in feeble-mindedness may occur before, at, or after birth, by far the greater number being congenital. There is even some doubt but that many cases supposed to occur from causes acting after birth may have been congenital in their origin, the condition having gone unrecognized until aggravated by illness, injury

[1] A. C. Rogers, M.D., "Classification of the Feeble-minded Based on Mental Age," *Bulletin American Academy of Medicine.*

or faulty environmental conditions. It has long been the custom to hold defective heredity responsible for a large proportion of feeble-mindedness. Heredity undoubtedly does hold a prominent place among the etiological factors, yet it is doubtful whether heredity, in its true scientific meaning, can be held responsible, as has been stated, for over one-half of all cases of feeble-mindedness. We must not lose sight of the fact that our knowledge of the workings of heredity and the transmission of characteristics is as yet very incomplete. To heredity can be attributed only those characteristics which are the property of the individual at the beginning of that individual's existence, for after existence has begun any condition set up by outside influences, as injury, intoxication or infection, is manifestly acquired and there is pretty general agreement among scientific men that acquired characteristics are not inherited. Individual existence does not begin with birth but at the moment of fusion of the nuclear material of the spermatozoon with the nuclear material of the ovum, resulting in the fertilized cell. Thus only that can be inherited which has been possessed by the spermatozoon or the ovum, or which results directly from the fusion and interaction of the two parental cells.

Thus in finding a cause for any given case of feeble-mindedness we must carefully separate from inherited states conditions acquired during the intra-uterine existence of the individual. This is very often a matter of great difficulty, even when necessary data regarding family and puerperal history are easily obtainable, and very often it is impossible. For this reason much of the statistical matter regarding the influence of heredity in the causation of feeble-mindedness is misleading, to say the least. But while we may not contribute to the view that direct heredity is responsible for as large a proportion of feeble-mindedness as has been attributed to it, we nevertheless must concede that parental conditions have a very great influence in its production. While the researches of Davenport, Goddard, and others have so far failed to reveal a single instance in which two feeble-minded persons were the parents of normal children, even such evidence is not proof conclusive of the inheritability of feeble-mindedness as an homogenous condition, but can better, I believe, be explained on the basis that degeneracy, because

of impotency of the germ cell from conditions acquired by one or both parents or because of chemical influence during intra-uterine development, results in degeneracy. If we consider feeble-mindedness, as we should, as but a condition of arrested development or imperfect organization of the nervous system we greatly improve our case against heredity. We can then increase our etiological hereditary factors to include all conditions of faulty nervous organization. But here again we are treading upon dangerous ground when we attempt to generalize from the particular. It is undoubtedly true that in a great many cases of feeble-mindedness the causes can be directly traced to defective nervous systems in the forebears. In families with distinct neurotic taint, as the insane epileptic, alcoholic, hysterical and the like, feeble-mindedness is very likely to occur. But here we are confronted with the fact that there are any number of highly neurotic families whose children, though perhaps giving evidence of imperfect nervous organization, are yet not feeble-minded, but are on the other hand exceedingly brilliant. It has been stated that the "neuroses constitute perhaps, the most widely spread form of disease," and that "persons quite unaffected in this way certainly form the minority of the general population." [2] Yet feeble-mindedness while dangerously common is by no means universal, nor is there trustworthy evidence that it is increasing. As Dr. Southard has said,[3] "It seems hard for medical men to understand that most series of facts are a result of a conspiracy of factors, and in this conspiracy the hereditary and the non-hereditary factors may both play an important part. Which is the most important is the question."

While we will not admit that feeble-mindedness in any large proportion of cases is directly due to heredity, we are compelled to admit that very often it is a manifestation of incomplete nervous development in the forebears, though we must hold that such incomplete development or nervous instability is, in many cases, but a predisposing cause requiring an exciting factor during intra-uterine life, to result in defects of development sufficient to constitute feeble-mindedness. In such cases the condition is an acquired rather than

[2] Ernest Jones, M.D., "The Treatment of the Neuroses, Including the Psychoneuroses." White and Jellife's "Modern Treatment of Nervous and Mental Disease," vol. 1, p. 333.

[3] *Jour. A. M. A.*, Dec. 14, 1912, p. 2143.

an inherited one. We really know comparatively little regarding the complex chemical composition of the human body. We suspect, however, that it is not constant, and that there are changes in the fluid media surrounding the body cells, depending upon age, sex, environment, intoxication arising from without or from within, which exert marked influence upon cell resistance, growth and viability. That these changes may exert an influence not only upon the spermatazoon, the ovum, and upon the fertilized cell is not only possible but probable. Thus in regard to parental alcoholic intoxication, Forel makes the following statement, "The recent researches of Bezzola seem to prove that the old belief in the bad quality of children conceived during drunkenness is not without foundation. Relying on the Swiss census of 1900, in which there figures nine thousand idiots, and after careful examination of the bulletin concerning them, this author has proved that there are two acute annual maximum periods for the conception of idiots (calculated from nine months before birth). In the wine-growing districts the maximum conception of idiots at the time of vintage is enormous, while it is almost *nil* at other periods. Moreover, these two maximum periods come at the time of the year when conception is at a minimum among the rest of the population; the maximum of normal conception occurring at the beginning of summer. . . We may, therefore, assume that when a germinal cell leaves its gland at the moment when it is impregnated with alcohol, and achieves conjugation, it is unable to return to its normal condition for want of opportunity to be completely and promptly cleansed by nutrition and the circulation.[4] Several studies of a statistical nature dealing with the effects of parental alcoholism have been published by Professor Karl Pearson and his associates in the Francis Galton Laboratory of Eugenics in the University of London. The conclusions reached, broadly speaking, seem to show that alcoholism in parents has little injurious effect on their children. These conclusions, being entirely opposed to the general impression of many medical men and others, of course, raised a storm of dissent which has not yet altogether abated. Speaking conservatively, alcoholism would appear to be responsible for a greater number of births than would health without alcoholism, and there is much evidence derived

[4] Quoted from Ronald Campbell Macfie, "Heredity, Evolution and Vitalism," pp. 129, 130.

from experiments on animals treated by alcohol to show that their young, although in greater number, were much weaker. When alcoholism is added to degenerative conditions in the parents, such conditions are apt to be not only intensified in the offspring, but make their appearance at a relatively earlier age. Intoxications other than that of alcohol, and including infections, tend to manifest themselves in deterioration of the offspring. The effects are peculiarly liable to show themselves in the form of imperfect organization of the nervous system. This is in accordance with the principle, the action of which is repeatedly seen in evidence; that characters which are the last to be acquired by the race or the species are the first to be lost. In the evolution of man one of the last acquirements has been that of the higher mental organization. Thus the individual whose development has been arrested, by hereditary, parental or other cause, is peculiarly liable to present mental deficiency in some degree. This principle adequately explains the many cases of feeble-mindedness in which there are few if any gross physical stigmata. Among the diseased conditions in the parents holding a prominent place in the causation of feeble-mindedness, syphilis, tuberculosis and cancer hold a prominent place. Though we have been accustomed for years to speak of hereditary syphilis, transmitted or congenital syphilis is much the better term. Even though it is possible that syphilitic infective material may accompany the spermatazoon and so bring about the occurrence of syphilis in the offspring, this would be infection rather than heredity. While of late years doubts have been accumulating relative to congenital syphilis "unto the third generation," certain positive cases have been reported. "The *rationale* of this seems plain in view of the observations of recent years made by Levaditi, Bab, and others, that Treponema pallidum may be found in the ovum, and in an apparently resting stage similar to the resting stage known for other flagellate protozoa causing syphilis." [5] It is, however, held by some that the manifestations in the third generation are not directly syphilitic, but are due to conditions consequent upon the degeneration effected in the precceding generations, and not upon direct influence of the

[5] Smith Ely Jellife, M.D., "Treatment of Syphilitic Diseases of the Nervous System," "Modern Treatment of Nervous and Mental Diseases," White and Jellife, vol. 2, p. 417.

disease. With very few exceptions it would seem that in congenital syphilis the disease was contracted from the mother by infection. Even when the mother shows no actual manifestations of the disease, it is still possible that she is suffering from a latent form for it is hardly possible that she would possess the immunity which allows her to suckle her syphilitic child with impunity if such were not the case. Syphilis undoubtedly plays a larger part in the production of feeble-mindedness than is usually attributed to it. Though the early statistics are comparatively worthless, they are quoted at great length even in modern works on the subject. "The early English, German, and American figures varied from 0.1 (Shuttleworth) to 17 per cent. (Ziehen). Whereas, the results following serological investigations start with the higher figures, and mount upward in some cases as high as 40 per cent. The American figures available (Atwood and Clark) show that 20 per cent. of the idiots, imbeciles, and morons at Randall's Island, New York, were syphilitic.[6]

Tuberculosis and cancer are often found in members of a family in which there are feeble-minded individuals. This is also true of families in which there is increased susceptibility to various infectious diseases. In these cases we have the toxins of the infectious disorder circulating through the system, becoming absorbed by the germ cells and acting chemically upon the idioplasm. The frequency with which one is confronted with the history of parental infection in cases of various monstrous developments has been noted.

Diseases, conditions and injuries affecting the mother during her pregnancy may result in feeble-mindedness either through chemical or mechanical influence. Thus, infectious diseases, exhaustion, over-work, faulty hygiene, emotional disturbances, shock, jars, blows and falls, all may have etiological significance. Perverted glandular activity would seem at times to exert an influence disproportionate to its apparent influence on the general health of the mother.

In spite of the popular belief in maternal impressions, which is extraordinarily prevalent even at the present day, all cases of so-called maternal impressions are probably coincidence. It is entirely possible, however, that through the effect of sudden shock of the

[6] *Ibid*, p. 420.

nervous systems changes in nutrition or in glandular secretion are brought about which result in the production of deformed and feeble-minded children.

The causes acting at birth are mostly traumatic. The first-born and male children are particularly liable to such injury to the head and brain. Feeble-mindedness very often develops from prolonged and difficult labor, and from instrumental delivery. While it would seem and has been alleged that instrumental delivery is accountable for a considerable amount of cerebral injury and consequent mental impairment, Shuttleworth's and Fletcher Beach's statistics[7] show that protracted pressure without instrumental interference is also a potent cause both of mental and nervous defect, the latter factor figuring more than four times as often as the former (*i.e.*, 14.24 per cent., as compared with 3.31) in their combined etiological table, whilst in addition the occurrence of *asphyxia neonatorun* is noted in 12.96 per cent. of Doctor Beach's cases.

Under causes acting after birth fall all pathogenic agencies, traumatic, toxic and nutritional. The brain of the infant and young child is an extremely delicate organ undergoing very rapid development, and causes which are apparently trivial, may initiate an arrest in its development, with far reaching results. Of the more usual causes acting in infancy and early life are: Cerebral and meningeal hemorrhage; meningitis, the infectious diseases, as scarlet fever; conditions causing convulsive seizures, particularly epilepsy. Malnutrition may be a cause. Lately the importance of abnormalities of the glands of internal secretion has come to be recognized. Though cretinism has long been known to depend upon deficient thyroid secretion, the real importance of this and others of the internal secretions was not clearly recognized. Of external poisons, alcohol and opium have been known to have caused feeble-mindedness. Trauma is frequently mentioned and sometimes is a cause, but it is often a very difficult matter to prove the relation. Loss of one or more special senses or their absence from birth, may result in failure of development of other portions of the brain, and the individual become feeble-minded by deprivation.

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[7] Shuttleworth and Potts, "Mentally Deficient Children," p. 88.

PATHOLOGY

The lesions in feeble-mindedness are both gross and microscopic. The gross lesions may consist of tumors, areas of sclerosis, meningeal thickenings and of defects and malformations. Thus the cortical convolutions may be absent, or imperfectly developed; or the basal ganglia may be absent; the corpus callosum is sometimes totally deficient, as are also both lobes of the cerebellum. In case these defects have been caused by intracranial hemorrhage, large cysts are often found. Porencephaly and hypertrophy and true microcephaly of the brain are comparatively rare conditions. On the other hand hydrocephalus is common, existing either as an independent or a complicating lesion. In contrast to those cases in which gross defects exist are those in which the brain as a whole is normal both as to architecture and size. But, in these cases microscopical examination shows defects in the ganglion cells of the cortex, which are both fewer in number and imperfect in development. While in general it may be stated that the greater the gross anatomical defect the greater is the degree of feeble-mindedness, this rule is not absolute, and cases are on record in which gross lesions were associated with considerable intelligence. On the other hand brains of fairly normal outlines have been found in cases of profound idiocy.

DIAGNOSIS

The diagnosis of feeble-mindedness may be one of the simplest or one of the most difficult tasks with which the physician is confronted. In cases patently feeble-minded, the idiots and low-grade imbeciles, especially when they are distinguished by certain type characteristics, such as cretinism, mongolism, microcephaly, hydrocephalus, etc., the diagnosis to the expert is so easy that even "he who runs may read." Even in the higher grades certain characteristics may be so pronounced as to leave little doubt in the mind of the examiner as to the real status of the case. But, except in the most obvious cases, it is not well for the physician, no matter how experienced, to trust too much to his intuitive diagnostic ability, for intuition ofttimes goes astray, with consequences which may be disastrous to the future of the patient. For this reason a most minute and searching inquiry should be made into all facts having even the

most remote bearing. These should be carefully and conscientiously weighed and the proper significance given to each, even forgetting, for the time, preconceived opinion of the importance of heredity, physical stigmata and mental tests.

Every examination should be made as complete as is possible under the condition existing at the time. In the clinic, the schoolroom, the room of detention of the juvenile court; even in the physician's office it is often impossible, or inexpedient to obtain all the data which might be desired. The examiner must then draw his conclusions from whatever material is available if he can do so conscientiously. If not, he should decline to give a positive diagnosis until more complete data is obtainable. Some cases may be disposed of very quickly with only one examination; others require numerous ones and in addition recourse to investigators in the various fields of medical practice, as the serologist, ophthalmologist, röntgenologist, etc., and in some observation and study extending over years is required.

The diagnosis is based upon facts brought out in:

1. The family history.
2. Developmental and social history.
3. Physical examination.
4. Mental examination.

I have already, in speaking of heredity, attempted to show that a familial tendency toward degenercy is of more importance in the etiology than is direct heredity. It should be noted here that the term *degeneracy* is not used with its usual implied sense of opprobrium.

When there is plain evidence of a psychopathic or neuropathic family history it should be given proper weight and is often a great value in making a diagnosis. Such a history is more often present in institution work than in private practice. Dana has said,[8] "In my own experience, in the study of the backward children or the idiot class, in which the idiocy was apparently begun at birth, it has been rare to find anything in the ancestors which would explain it, and among the idiot class that come to a private physician's office, I should say that the determining influence, in most cases,

[8] C. L. Dana, M.D., "The Modern Views of Heredity, With the Study of a Frequently Inherited Psychosis," *Medical Record*, Feb. 26, 1910.

could be traced to something which occurred when the child was in the embryonic state. This is not altogether the case in the great mass of idiots found in institutions."

DEVELOPMENTAL HISTORY

The developmental history of the child properly begins at the moment of conception, consequently it is necessary that developmental and environmental history be studied together. There is a strong basis for the belief that the germ plasm may be influenced by the nutritional fluids which surround it, especially by the presence in those fluids of various toxic substances such as have been mentioned above. For this reason a careful inquiry into the history of the pregnancy should be made, not only for the conditions before mentioned, but for blows, falls and other disturbing factors. The duration of labor, the position of the child *in utero,* whether delivery was instrumental or natural, all have an important bearing. It is of value to learn whether the child cried immediately after birth, as meningeal hemorrhage may not only simulate, but is a frequent complication of asphyxia neonatorum. Asphyxia also occurs in premature infants and in those which, though full term, have undeveloped nervous systems. It is very common to find a history of birth asphyxia in the feeble-minded when the labor in every other respect was normal.

The state of nutrition during the early months, the time and order of dentition, the acquisition of muscular control as shown by the ability to hold up the head, sit up, crawl, stand and walk are items of considerable diagnostic importance. Delay in walking, after the elimination of rickets and paralysis, is strongly suggestive of feeble-mindedness. It must be determined, however, whether the child fails to walk because of physical inability, or because he lacks the mental power to properly direct and coördinate his movements. Delay in the acquisition of speech is likewise strongly suggestive, though in this matter we must not be unduly hasty in arriving at conclusions. We must first eliminate deafness, partial or complete, as well as word-deafness. Moreover, there are children, otherwise normal, in whom the development of speech is physiologically slow. In others, unusual ability to make their wants known by gestures and signs removes the necessity for expression by other means. How-

ever, a history of marked delay in beginning to walk and talk, in the absence of other causes, is strongly indicative of feeble-mindedness. Trauma and the acute infectious diseases are the most frequent causes of acquired feeble-mindedness. Before attributing the condition to one or the other of these causes, however, it is necessary to study carefully the developmental history before the time of action of the suspected cause. Very often there will be found several factors in the etiology. For instance, it may be found that a child showing poor heredity, born in a state of asphyxia, with walking and talking delayed until two or two and a half years, at the age of six has a severe attack of scarlet fever which leaves decided symptoms of cerebral involvement. The parents will likely date the mental abnormality from the time of the attack of scarlet fever, whereas the child may really have been feeble-minded from birth.

For convenience in comparing the development with that of the normal child the following brief chart is inserted.

DEVELOPMENT OF NORMAL CHILD

First Month.—Sensitive to light as early as first and second days. Infants have been noticed to close the eyes in response to the stimulation of a strong light within an hour after birth. Pleasure is shown in light of candles and in bright objects as early as the eleventh day. Hears on fourth day. Discriminates sounds last two weeks of month. Starts at gentle touches second and third days.

Sensibility to taste occurs about end of first week. Mimetic movements are produced by strong-smelling substances at birth.

Takes pleasure during first few days in nursing, in bath and in sight of objects.

Discomfort is produced during first few days from cold, wet, hunger, and tight clothing. Smiles on twenty-sixth day. Tears appear on twenty-first day. Vowel-sounds appear in first month, uttered by chance in crying. Memory is first active as to taste and smell; then as to touch, sight and hearing.

Movements of the eyes are incoördinate.

Sleeps the greater part of the time.

Reflexes are active.

Second Month.—Asymmetrical movements of eyes become less frequent and coördination is established, with occasional lapses.

Recognizes human voices and turns head toward sounds. Starts at loud noises and listens with pleasure to instrumental sounds, harmonious or discordant.

Laughing in response to tickling has been observed in sixth week.

Clasps with four fingers at eighth week.

About the end of the second month the first consonants are uttered.

Third Month.—Shows pleasure at sight of mother or father by cry of joy.

Eyelids not completely raised when child looks up. Improvement in accommodation. Listens attentively.

Fourth Month.—Objects seized are moved toward the eyes. Eye movements perfect.

Grasps at objects which are out of reach.

Shows pleasure in seeing self in mirror.

Power of setting thumb in opposition to other fingers is attained.

Holds up head without difficulty.

Begins attempt at imitation.

Fifth Month.—Discriminates strangers. Looks inquiringly.

Takes pleasure in crumpling and tearing papers, pulling hair, ringing a bell, etc.

Sleeps ten to eleven hours without food.

Shows wishes by stretching out arms.

Seizes and carries objects to mouth.

Consonants *l* and *k* appear.

Sixth Month.—Raises self to sitting posture.

Laughs, and moves arms upward and downward when pleasure is great.

"Crows" with pleasure.

Seventh Month.—Shows astonishment by open mouth and eyes.

Sighs.

Imitates movements of head, of pursing lips, etc.

Averts head as sign of refusal.

Places himself upright on mother's lap.

Eighth Month.—Shows astonishment at new sounds and sights.

Static sense and power of forming judgments of distance are sufficiently developed to allow accurate use of the hands in grasping.

Ninth Month.—Stands on feet without support.

Shows more interest in things in general.

Shows joy by striking hands together.

Shuts eyes and turns away head when something of a disagreeable nature is to be endured.

Shows fear of animals.

Will turn over when laid face downward.

Will turn face toward object when asked its location.

Many questions are understood.

Voice more modulated.

Tenth Month.—Sits up without support for long periods.

May make first attempts at walking.

In babbling hints at imitation.

Eleventh Month.—Sitting becomes habit.

Stands without support.

Stamps foot.

Repeats syllables correctly.

Uses consonants *b, p, t, d, m, n, r, e, g, k.* Of vowels *a* is used most, *u* and *o* rarely, and *i* very rarely.

Twelfth Month.—Consciousness of self appears.

Improvement of powers of locomotion; creeps.

Thirteenth Month.—Shakes head in denial. Says *papa* and *mamma.* Understands spoken words.

Fourteenth Month.—Walks with support.

Can raise himself upright by means of support.

Imitates motions of arms, etc.

Fifteenth Month.—Walks without support. Repeats syllables.

Sixteenth Month.—Runs alone, rarely falls.

Seventeenth, Eighteenth, and Nineteenth Months.—Associates words with objects and actions.

Executes complex acts, as: blowing horn, striking with hand or foot, washes hands, combs and brushes hair, as well as other imitative movements.

Twentieth to Twenty-fourth Month.—Pretends to read newspaper.

Marks on paper with pencil.

Very few of his expressions are recognizable.

Attempts to sing and beat time and to dance to music.

Executes orders with surprising accuracy.

Twenty-fifth to Thirtieth Month.—Is able to distinguish colors.

Forms sentences of several words.

Begins to ask questions.

Begins to climb and jump.

Emotions increased in complexity.

Uses personal pronoun "me" at this time or somewhat later.

Is soon followed by substitution of "I" for "me."

Thirtieth to Fortieth Month.—Climbs stairs without assistance.

Sentences are correctly applied and clauses formed. Words are distinctly spoken, but the influence of dialect appears.

Questioning is repeated to weariness.

Approximates manner of speech to that of the family more and more.

While the child's development follows no arbitrary rules, and delay in the acquisition of some particular function or faculty may be entirely within the range of normal, yet an unreasonable delay especially if in conjunction with other suspicious data is strongly suggestive.

PHYSICAL EXAMINATION

When the cerebral disorder or defect is accompanied by striking physical peculiarities or malformations, we are not only aided in the matter of diagnosis, but are able to classify the type.

The majority of the feeble-minded present no special distinguishing features other than the anatomical and physiological anomalies (hypoplasia) common to the class in general.

Stigmata of Degeneracy.—There are few of us who would escape if we were to classify as degenerate all those who present the so-called stigmata. There are, undoubtedly included in this category many anomalies which, at the worst, are but biological variations within health limits. As Tredgold says,[9] "We have not yet reached finality,

[9] A. F. Tredgold, "Mental Deficiency," 1908, p. 79.

and manners, morals, mind, and physiological function, even anatomical structure, are, we trust, still in process of evolution; so that it is possible for some of these anomalies described as "stigmata" to be not retrogressive, but actually progressive."

While similar anomalies occur in individuals who are not otherwise abnormal, they are more numerous in the psychopathic and the feeble-minded and their presence in any number, while not necessarily pathognomonic, should lead us to a careful examination.

Among the clinical types presenting characteristics sufficiently marked to allow very often of diagnosis from inspection alone are the

1. Microcephalic.
2. Mongolian.
3. Cretin.
4. Paralytic.

Microcephalus is generally considered to be present when the skull measures less than 17 inches in its greatest circumference. It is well to remember that the actual brain capacity is usually less than the circumference would indicate, as the deficiency lies chiefly in the upper parts of the skull. There is a marked deficiency in the frontal and occipital regions of the cranium. This causes a cone-like shape to the skull which taken in conjunction with the markedly receding chin, gives a very characteristic bird-like appearance to these individuals. The condition is usually accompanied by greatly diminished stature.

Mongolian Type.—The *Mongolian* or *Kalmuc* variety of feeble-mindedness is so named from the resemblance of these individuals in certain particulars to members of the Mongolian race. The appearance and characteristics of the individual of the typically Mongolian type is so distinctive that, as has been said, these children "resemble each other so closely that they appear to be members of the same family." [10]

It has been estimated that five per cent. of all imbeciles are Mongolian and that from ten to fifteen per cent. of all children who in infancy are recognized as mentally defective.[11]

[10] G. A. Sutherland, "Mongolian Imbecility in Infants," based on a study of twenty-five cases, *Practioner*, Dec., 1899. Quoted from Tredgold.

[11] J. Murray Bligh, M.D., "Mongolianism," *Liverpool Medico-Chirurgical Journal*, July, 1910.

Syphilis has for years been given a prominent place by different investigatiors in the etiology of this condition. Some writers putting the percentage as high as fifty per cent. and above while others believe that the incidence is no greater than in the general population. My experience leads me to incline to the latter view. It is an interesting fact that Mongolianism, as a rule to which there are many exceptions, occurs in the last individuals of large families born during the years of declining sexual life. There are exceptions, however, as I have seen Mongolian children whose parents were in the early twenties. I have, however, yet to see a case in which careful anamnesis will not show debilitating causes of one kind or another prior to conception or during pregnancy. Even grief, worry, and other long continued states of emotional upheaval seem sometimes sufficient to curtail the normal legacy of vital energy from parents to child. Attempted abortion has been mentioned as a cause. None of these causes, however, which are active in forms of mental deficiency other than the Mongolian as well, explain the uniformity of facial characteristics common to the Mongolian. Sajous[12] believes that the Mongolian facies is not a mere result of hazard and attributes it to a biochemical source. He refers to the fact that lack of fresh fruits and vegetables causes scurvy and also that beriberi results from a monotonous diet composed chiefly of polished or overmilled rice and that rickets and marasmus are produced through an excess of starchy foods. He states that the Mongolian race, the coolie element particularly, shows the influence of centuries of unbalanced diet, and refers to investigations which have shown that the outer layer of rice, removed during the process of milling is that which contains soluble organic compounds rich in phosphorus. As the deficiency of phosphorus, in the form of phosphorus pentoxide, in milled rice has been identified as the passive cause of beriberi, so, in individuals who through a long line of forbears have become habituated to its use, phenomena of another order become manifest, *viz.*, "those of deficient development of tissues in which phosphorus is the preponderating agent, the *osseous and cerebro-spinal systems and also primarily of the thymus gland which, through its nucleins, insures the development of these systems.*

[12] Charles E. de M. Sajous, M.D., "Hemadenology," Ninth Communication. *New York Medical Journal*, June 12, 1921.

Analyzing the pathogenesis of Mongolian idiocy from this standpoint, the kinship between the characteristic features of this disease and the attributes peculiar to rice-fed Mongolians is striking. The small size of the Japanese, Siamese, Tonkinese, Annamites, etc., the slanting eyes, the narrow palpebral fissure, and the epicanthus, especially marked in the Chinese, and the high cheek bones, are also peculiar to the Mongolian idiot. "In the yellow race, so-called, the skin is pasty, yellowish, doughy, but smooth; the hair is straight, the nose is squatty, exposing the openings of the nostrils—all morphological characteristics of the Mongolian idiot. Another peculiarity of the latter is his predilection to infection and the deficient resistance shown to infectious diseases; we know how easily rice fed Asiatic coolies acquire such diseases and succumb to them. That the mentality is not necessarily dwarfed in the rice fed Asiatic, as it is in the class of patients in question, is doubtless due to the adjustment of his nervous system to his deficient diet throughout the thousands of years he has used it." The characteristics of the typical Mongolian are so strongly marked that diagnosis is simple. A characteristic symptom is brachycephaly, that is, the transverse diameter is excessively large in proportion to the shortened anterior-posterior diameter; the occiput is flattened. One of the most obvious signs of the condition is the slanting direction of the eyes, they are closer together than in the normal child and the axes of the small palpebral fissures are more oblique. The outer canthus being higher than the inner; the epicanthic fold of skin at the inner angle is markedly developed.

Due to the sensitiveness of mucous membranes common to these children, blepharitis is usually present. Strabismus is almost the rule. The nose is snubby with a depressed bridge. The tongue usually protrudes and because of the ensuing hypertrophy of the fungiform papillæ becomes granular and later fissured. The skin is dry, mottled, chaps easily and is often furfuraceous. The cutaneous and subcutaneous tissues of the Mongolian give when grasped a peculiar feeling which baffles description but which differs from that of the tissues of other individuals. The hands are chubby and the little finger usually curves inwards. The abdomen is usually protuberant. Laxity of the joints is a most striking character-

istic, Bullard[13] mentions one who was accustomed to shut himself up like a jack-knife each foot on the opposite shoulder and thus sleep at night. Ossification of the bones is delayed. The intelligence of the Mongolian may vary from a close approach to the normal to absolute idiocy—though imbecility is the rule. He readily gives way to exaggerated expression of emotion; is just as easily moved to laughter as to tears. He is highly imitative, often mischievous, usually fond of music and being a vertible "busybody" finds amusement and occupation with ease. When properly trained he is easily managed, but when over or under disciplined is apt to be troublesome. He responds to education less easily than superficial observation would lead one to expect, chiefly because of lack of concentration and over free association.

The Cretin.—The typical cretin belongs to the idiot class, though the affection may range upward in degree until the individual very closely approaches the normal. The cause is an absence or deficiency of thyroid secretion. Cretinism is most common in Europe, in the mountains and valleys of Switzerland and adjacent countries, and also occurs in endemic form in the Rocky Mountains of the Northern Continent and Burmah and Macedonia. No portion of the globe is entirely free from this condition, and while its incidence in our own locality is not by any means so great as in other countries, yet a considerable number of sporadic cases always exist. In the endemic form as seen in Switzerland a large goitre usually coexists, while in the sporadic cases as seen in this country the thyroid gland is usually entirely absent. In both varieties there is an absence or marked deficiency of the thyroid secretion. The characteristics of the typical cretin are. Marked dwarfism, the adult cretin often being not more than three feet in height. The head is usually large; the legs short and bowed, and the hands and feet stumpy and ill-formed. The nose is broad and flattened, the eyes widely separated, the lips thick, the mouth partly open, and the tongue thick, coarse and protruding, the eye-lids are heavy and swollen, and the hair coarse and scanty. The skin is sallow, dry, rough and so loose as to appear too large for the body. The neck is short and thick and the abdomen protuberant. Often there are soft fatty swellings above the

[13] William N. Bullard, M.D., Boston, "Mongolian Idiocy," *Boston Medical and Surgical Journal*, Jan. 12, 1911.

collar bones and in the arm-pits. These individuals are usually voracious eaters, but while well-nourished and even fat, suffer from a general bodily weakness which in conjunction with the mental sluggishness, renders them clumsy and unsteady in their movements and waddling in their gait.

Mentally these children are characterized by a general obtuseness in all their faculties. The milder cases are educable to the point of learning to read and write short words and to do simple sums in arithmetic, and be made capable of assisting in the domestic work of an institution. As a class they are the least troublesome of all the feeble-minded. The results of treatment by supplying the deficient thyroid secretion by artificial means (administering preparations of the thyroid gland obtained from sheep and other animals) are often favorable and even brilliant when such treatment is begun early, before grave retrograde changes have occurred in the organism as a whole. The results are especially gratifying in the milder cases.

Paralytic cases.—Paralysis of one, two or more limbs is a frequent complication of feeble-mindedness. The causes are: Lack of development of the nervous system in intra-uterine life; birth injuries causing organic lesions in the brain; organic brain injuries at a later period due to trauma or acute infectious disease. The paralysis is of the spastic type, the muscles remaining in a chronic state of contraction, the limbs eventually becoming more or less fixed in a flexed position. Not all cases of spastic paralysis, however, whether due to incomplete development or to trauma are feeble-minded, as normal mentality is not incompatable with a high degree of paralysis.

Other types than those described above, in which the appearance alone leads to a strong suspicion of feeble-mindedness are those due to abnormality of the pituitary gland resulting in infantilism, in which condition there is marked physical retardation, gigantism with its bodily overgrowth and mental insufficiency, and dystrophia-adiposis sexualis, in which with an overgrowth of fatty tissue there is almost complete absence of secondary sexual characteristics.

The great majority of the feeble-minded, however, and especially of the higher grades belong to no particular type, though many possess characteristics in common which place them in certain general groups. There are two main types of the feeble-minded as there are of normal individuals, the quick active hyper-energized type and the slow leth-

argic under-energized. In each the determining characteristic is exaggerated over what it would be in the normal. Superficial fleeting attention marks the first, lack of attention the second. As a rule the first type is undersized, with small bones and small features, while in the second, though the stature may or may not be below normal, the framework is heavy. Both types usually present stigmata of degeneracy as overshot or undershot jaw, misshapen ears, squint and defects of vision, etc., but it is not the mere presence of these stigmata, which are also found in normal individuals, but the general ensemble that is significant. While in repose it might be impossible for one to state which of two individuals is the feeble-minded one, the moment both begin to react to given external stimuli, the observer is often able to make his determination with ease. However, as I stated earlier, it is not wise to depend too much upon one's intuitive abilities, and because of this, and because it sometimes happens that observation gives but little aid, it is necessary to employ more exact methods of diagnosis.

MENTAL EXAMINATION

A few years ago the news was blazoned forth that a method of diagnozing feeble-mindedness with mathematical accuracy had been discovered, and soon all sorts of lay amateurs, armed with a set of Binet-Simon tests were assidiously examining any victims the school authorities and social agencies would entrust to their tender care. Not only examining, but diagnosing and making recommendations which would serve to change the whole course of the individual's life. I have no quarrel with the Binet tests; as an aid to diagnosis in the hands of an experienced observer, they are of great value; but neither they nor any other tests are infallible instruments of precision. They fulfill the same purpose in mental diagnosis that the clinical thermometer does in the diagnosis of diseased states. They tell us, like the clinical thermometer that an abnormal condition exists, but they give us little information regarding the cause, the character, or the prognosis. This information must be gained through close study and careful evaluation of other clinical material. Through the wide-spread use and overconfident reliance upon the Binet-Simon tests, many individuals have been designated as feeble-minded, who in reality are not feeble-minded at all, and as a result many of the

statistics on the incidence of feeble-mindedness are misleading if not actually worthless.

It is my custom not to rely to an undue extent upon the result of psychometric tests, but to base the diagnosis more upon the history and upon the clinical characteristics, and to reserve, or at least give only a tentative opinion until subjection to proper corrective influences have furnished the "acid test" of the individual's ability to conduct his affairs with ordinary prudence. This method has been particularly useful in Juvenile Court work. We have in Western Pennsylvania, at Thorn Hill, a most excellent industrial school for Juvenile Court boys. Situated on a farm of about twelve hundred acres, its four hundred and some boys have every opportunity for healthful outdoor exercise, a substantial diet, mild discipline and well-directed educational advantages. Several years ago, it was my custom to recommend Polk, our institution for the feeble-minded, for many boys who, while belonging to no definite clinical type, were shown by the Binet and other tests to be so retarded it seemed there could be no question of their being feeble-minded. Because, however, of the crowded condition of Polk, these cases were sent to Thorn Hill to be transferred whenever vacancies existed. In some instances these boys remained at Thorn Hill for one, two and three years and were examined by me at those intervals. To my surprise and gratification, I found it unnecessary to transfer more than a small proportion to Polk. The others went on, out into the world and have, I believe, conducted themselves with as much credit as the boys who were never considered feeble-minded at all. As a consequence it is now my custom to recommend in all doubtful cases that before recourse is made to an institution for the feeble-minded, a trial of what may be accomplished through a favorable environment be made. There are psychologists whose confidence in mental tests is so great that they hold that a diagnosis may always be made on the result of such tests alone and from one more or less extended examination. I believe this is a dangerous belief, the spread of which should be discouraged. One can, of course, gain a fairly good idea of the present state of mental development of an individual from one examination but can only surmise the inherent possibilities for development under proper influences. *Mental tests do not measure potentialities.* Feeble-mindedness is not a clinical entity, but rather one symptom of

a complex group of symptoms indicating abnormality of physical structure. The mind is but a function of the brain, and when we measure we are measuring a few of the tangible evidences of brain function as shown under certain conditions arbitrarily selected. I *have always held that critical observation of an individual's reaction to a selected environment is the best test of his potential ability.* However, as such extended observation is impracticable in most cases we must use the best means at hand and are forced to place a large degree of dependence upon mental tests.

BACKWARD CHILDREN

We will consider that the backward child is one who is retarded in his development by reason of some conditions either inherent in the child himself, which can either be removed or counteracted, or who is subject to some physical defect or environmental condition the removal of which will allow him to progress in a normal manner under favorable opportunities. It is a matter of difficulty to accurately pigeon-hole and classify children of any kind, but the following, however, will answer the purpose:

First, those backward by reason of change of school and absence therefrom for various reasons.

Second, those of uniformly slow rate of physiological development.

Third, those retarded because of biological variations in special cerebral centres making up the zone of language.

Fourth, nervous, unruly children.

Fifth, those retarded because of physical defects, which can be either removed or counteracted.

Those Backward by Reason of Change of Schools.—This class is one with which the city teacher, particularly in the congested and foreign districts, must frequently deal. The foreign-born child is of necessity greatly handicapped in his school work, whether he has come to this country before or after the beginning of his school life. Although these children pick up a new language with wonderful facility, it very often takes them some time to adjust themselves to new habits and customs. Again, they often hear nothing but their native tongue except when at school or playing with English speaking companions. If, as sometimes happens, they are kept much indoors and with children of their own nationality entirely, their

opportunities for adaptation are few. I have seen cases in young children under school age in which I attributed inability to talk to the fact that the children, kept indoors all day, heard nothing from the parents but their own language and the English language only from their brothers and sisters. The mental confusion consequent upon this condition prevented the child from attempting to speak at all. Frequent change of schools, very common in all classes and conditions, but more particularly among the poor and improvident is a prolific source of retardation, for on account of the consequent change of teachers, methods of teaching, and surroundings, a more or less lengthy interval of time elapses before the child is able to adjust himself to the new conditions. Frequent change is also liable to affect the child's ability to concentrate properly. Absence from school whether from illness, truancy or other causes, for obvious reasons, causes the child to fall behind in his school work. There are certain conditions, however, under which absence from school may be of benefit. A child who is convalescent from illness, is undernourished or excessively nervous is better off outside of the schoolroom, in the open air, and will often be able to more than regain the ground lost through his absence.

Those of Uniformly Slow Rate of Physiological Development.—All individuals do not develop either physically or mentally at the same uniform rate. Chronologic, physiologic, and anatomic age are not identical, as has been proved by the researches of the late Doctor Rotch of Harvard and other observers. It is absurd to expect the child who is chronologically ten years of age, but physiologically but seven or eight, to undertake the duties of the normal child of ten. To do so is to lay the train for some of the nervous disorders to which such children are subject.

Those Retarded Because of Biological Variations in Special Cerebral Centres.—In a paper, read before the Pennsylvania Medical Society about 12 years ago I discussed a cause of backwardness in school-children which I think is more common than is generally supposed, namely congenital word-blindness, and reviewed the cases to be found in literature, besides reporting a case which had come under my own observation. Claiborne, under the term congenital symbol-amblyopia includes this condition with an incomplete congenital figure blindness, he also describes incomplete congenital word-

deafness as amblykusis and postulates an incomplete congenital musical-note deafness which he terms amblymusia. He later includes stuttering in this class of defects. I will take up these conditions, in which I will include delay in the acquisition of speech, in detail.

Congenital word-blindness or word amblyopia is a condition which interferes with the stamping of word images upon that particular portion of the brain which through inheritance from generations of reading and writing ancestors has become specifically developed for their reception; the angular gyrus either alone, or in association, with part of the supra-marginal lobule. That word-blindness occurs as a result of defective development, either intra-uterine or as the result of injuries received during labor there is no doubt, but on account of the distinct hereditary and familial influence shown in a large number of the cases reported, and the lack of history of prolonged labor or birth injury, the evidence would seem to be greatly in favor of the condition being ontogenetic in origin. The term "biological variation" was suggested to me by Dr. Lightner Witmer for uses in describing this class of cases. I will use it hereafter both for congenital word-blindness and conditions related to it.

Since the report mentioned above, many other cases have come under my observation. One I exhibited before the College of Physicians, Pittsburgh, in February, 1910, and others I have described in various articles. The following from my case records of a word-blind boy shows mistakes which are typical, "z he calls s, l he cannot name at all, r he calls b, p he calls r, l he calls t, t he calls f, etc." He is unable to read the simplest words, calling "dog," you and "yes," our. "May," "did" and "on" he would not attempt. His recognition of numerals was good. He can do simple multiplication, addition and subtraction.

About half of the cases of word-blind children are also letter-blind, while but a small proportion are unable to recognize figures. In fact, some of them are unusually good at arithmetic and the facility with which the case under discussion recognizes musical notes has been noticed in others. As I have remarked in the article alluded to, although but some 40 cases had at that time been closely observed, though a considerable number have since been reported, it appears that this number represents but a small proportion of those affected, and that systematic school inspection and closer study of backward

children in the consulting room and the clinic will show that this is not at all a rare condition. Thomas calculates that one in two thousand of all London elementary school-children may be expected to show word-blindness to a considerable extent. It is of the utmost importance that these cases be diagnosed and the proper educational treatment instituted while the child is still young enough to profit by it.

FIGURE-BLINDNESS OR AMBLYKUSIS

A small proportion of patients subject to word-blindness will show figure-blindness in some degree, although as stated above, some are exceptoinally good at arithmetic. Congenital figure-blindness to any marked degree unassociated with word-blindness has not, I believe, been described, though in speaking of acquired aphasia, Bastian says "on rare occasions it has been found that loss of ability to read and comprehend numerals exists in the absence of word-blindness." Taking these facts into consideration it would seem that the visual impressions derived from numerals are registered in a brain region which is slightly removed from the visual word centre. Children will be found who while able to recognize the letters of the alphabet both singly, and when combined to form words are unable to recognize or remember numerals, especially when in combination. These children are very likely to be bright in subjects in which figures are not required, though as in word-blindness, occasional instances will be found in which the lack of cerebral development is more or less uniform.

CONGENITAL WORD-DEAFNESS

Of all the centres concerned in speech the integrity of the auditory centre is of the most importance.

Thought in its higher manifestations cannot be carried out without the aid of language of some kind. The most used and most important means of expression is through speech. The proper development of speech is dependent not only upon a perfect peripheral hearing apparatus (the ear) but also upon a perfect auditory centre. Congenital deafness always entails mutism, as does acquired deafness occurring before the child has learned to talk. Even the child of five or six years who has learned to talk will upon becoming deaf forget how to speak. Under these conditions there is an arrest

of development in the auditory centre secondary to the peripheral lesion. In word-deafness the trouble lies in the auditory word-centre, "the cortex of the middle and posterior portions of the first temporal convolution, extending over into the second temporal and upward into the supra-marginal convolution, where it impinges upon the cortical area for visual images." In this condition words are heard merely as noise, or, it may be that impressions only of certain sounds making up words may be received. In either case the cerebral development in other directions, may, except in so far as it is dependent upon this important centre, be normal.

IDIOGLOSSIA

Of idioglossia, which I believe to be due to partial word-deafness, Bastian says "some curious cases of congenital speech defect were described by Hadden to which the term "idioglossia" has been applied. These children have to a certain extent a language of their own, so that when asked to repeat phrases they make use of different, though definite, sounds instead of those proper to the words that should be employed. The sounds which they substitute are said to be always the same for the same words. Some of these patients have been capable of writing from dictation, and they have also shown a fair amount of general intelligence."

Guthrie devotes an entire chapter to this subject in his book on "Functional Nervous Disorders in Childhood." After reviewing the cases to be found in medical literature he reports in detail a number of cases which have come under his own observation, and drawn the following conclusions:

1. The term idioglossia is legitimate as representing the condition of a well-marked group of cases.

2. Idioglossia is neither a spontaneously invented language nor an example of atavism, nor a "sport" in language. It is not to be confounded with baby language nor with the language of imbeciles, although it bears a superficial resemblance to them. It is not evidence of weakened intellect, but may possibly indicate hereditary taint of insanity.

3. Idioglossia is an exaggerated form of minor and extremely common defects in speech.

"Idioglossia does not depend upon malformation or imperfec-

tion of the motor organs of speech, but probably is chiefly due to congenital deficiency of audition not amounting to deafness."

"As such it has no more pathological basis than has the absence of a liking for sport, or a taste for art, or a sense of humor."

This condition is by no means rare, and as Guthrie states, "should not be confounded with baby language nor with the language of imbeciles."

Upon being confronted with a child with idioglossia the temptation would be to put it down as feeble-minded. These cases come very often under the observation of those who have much to do with feeble-minded and backward children and it is of the utmost importance to the future of the child that a correct diagnosis be made. As Coleman says, "Although the children are often intelligent and quick, the difficulty of making themselves understood gives other people the impression that they are idiots."

DELAY IN ACQUISITION OF SPEECH

Occasionally children will be found whose later development is normal in every particular who do not speak until five or six years of age. When word-deafness can be eliminated the possibility of retarded development of the motor speech centre, or its association pathways (either functional or structural) should be considered. It might be well at this point to speak of the influence of right and left handedness (or rather right and left-sidedness) upon the development of speech. It is not the purpose of this paper to enter into a discussion of the reason for the fact that in ninety-one per cent. of individuals the left side of the brain seems to be assuming control of the more complicated motor-functions performed by the right side of the body, while the right hemisphere attends more especially to the nutritive functions through the sympathetic system.

It is generally conceded that in right-handed individuals the complicated mechanism of speech is controlled by the zone of language in the left cerebral hemisphere.

"It must needs be admitted that there is a general auditory area, a general visual area, and a general kinæsthetic area in the right hemisphere, and that incoming stimuli make on it an impression similar to that which they do on the so-called "educated" hemisphere. These impressions are bilateral in reception, but unilateral in inter-

pretation. This unity of interpretation is determined by commissural fibres of the corpus callosum. Now the same factors that determine right-handedness determine also that the left-hemisphere shall be the executive speech side, but the elementary work is done on both sides."

An individual is congenitally either right or left-sided, consequently, the executive functions of his speech centres must assert themselves very early in his development, at the time when the only sounds he makes are purely reflex. General kinæsthetic impressions have a decided influence in the development of the speech centres as is shown by the marked improvement in speech as shown by cerebral hemiplegics after tenotomy. The more frequent and dexterous use of the muscles of one side would, therefore, assist materially in speech development. It would seem advisable in those children who use the left hand by preference, to allow them to continue doing so until the full development of language in all its manifestations, including writing, instead of forcing the use of the right hand, as is usually done.

In support of this theory I will report the case of a little girl of two and a half years who came under my observation.

L. A. First examined March 6, 1910. Family history negative except that a maternal aunt died of tuberculosis. Birth normal in every detail. Child was well formed and healthy, has never been really ill. Development in everything except speech, normal. Did not attempt to form words until one and one-half years of age, when she began to acquire a vocabulary of a few words in the usual way. About this time it was noticed that the left hand was used in preference to the right. Steps were taken to correct this tendency after which she suddenly ceased to talk. She used unintelligible phrases and gestures to denote her wishes. The child's mental condition was on a par with that of other children of the same age. Her appreciation of words and sounds was very good. Her articulatory organs showed nothing abnormal. After a week or two of special training with liberty to use the left hand freely she began to speak again at about the stage where she had left off.

AMUSIA AND AMBLYMUSIA

If we accept the theory held by Edgren and others that the different forms of amusia are dependent upon damage to special centres and commissures which are adjacent to, but not identical with, those

other centres damage to which gives rise to the corresponding forms of speech defect, we must assume that an auditory centre, for tones will correspond with the auditory word centre, kinæsthetic tone centre with the kinæsthetic speech centre, and a visual centre for notes with the visual word centre. In a congenital lesion or variation in the auditory tone centre there would be partial or complete tone-deafness. According to Bastian, "The existence of tone-deafness as an isolated and inherent defect is probably far from rare." There are persons who are incapable of discriminating between the two notes of an octave and who not withstanding the most frequent opportunities of hearing music remain quite incapable of distinguishing one tune from another.

Variations in the kinæsthetic centre or its commissures would account for the inability of some individuals to "carry a tune." There are some persons who while possessing a "musical ear" are still unable to reproduce what they have heard. It is interesting to note in this connection that idioglossia is sometimes associated with amblymusia as in the case of H. P. reported by Guthrie. It seems very likely that the imperfect appreciation of the various shades of difference in cadence and inflection of the normal voice might have a decided influence upon the causation of word-deafness.

STUTTERING

I fully agree with Claiborne that stuttering is due to a congenital defect and believe that the variation is one of this class. The subject of the relation of stuttering to amusia I have taken up in a paper published in 1910.

Congenital variations in the visual centre for musical notes is difficult to demonstrate, though it sometimes occurs that those who have attempted to gain a musical education have found it very hard to read music. With the exception of the influence upon stuttering of which I have spoken, the lack of development seems to bear no intimate relationship to retardation. Many men of great intellectual endowment have been totally destitute of the musical faculty and it is further a well known fact that in the feeble-minded it is often well developed.

CONCLUSIONS

Clinical evidence would seem to warrant the assumption that:

(1.) There are a large number of children retarded in their mental development on account of insufficient activity caused by biological variations of the special centres making up the zone of language.

(2.) That these children are very likely to be considered feeble-minded unless studied very carefully.

(3) That these children eventually become feeble-minded by deprivation unless their condition is exactly and early recognized and the proper treatment instituted.

NERVOUS, UNRULY CHILDREN

These furnish, perhaps the largest number of the pedagogically retarded, as they constitute many of the habitual truants, minor delinquents, etc., though usually, the scholastic deficiency is superimposed upon a foundation of nervous instability.

The character of an individual, his nervous and mental stability, depends upon inherent qualities of body and mind modified by the development of the normal powers of intellect, feeling and conduct; every stimulus with its corresponding reaction having its definite effect for good or evil. Psychopaths are both born and made. Not only may constitutional predispositions be removed or counteracted through early effort, but the foundations of future mishap may be laid through early neglect. The modern child is both overstimulated and undernourished. The hurried life of his elders, the inconsistencies in management, the preoccupations of either or both parents in business, society and the pursuit of pleasure, engenders an over tension in the family life which cannot but react harmfully upon the children. Even young babies are exposed to the myraid sensory stimuli of hurried city life, the street car, automobile, moving picture show, the incessant din of the phonograph and piano and the glare of the high-powered electric light. It is not unusual to see a motor cycle streaking along the road with a young child in its mother's arms bumping along beside it. Not long ago the parents of a two-weeks old baby took it out for a motor cycle ride, the baby, on their return, was lifted out—dead. Most

children survive the immediate effects, but it is hardly to be expected that no permanent damage to delicate nervous tissues will result.

The development of mentality is dependent upon impressions received through peripheral stimuli. Under ordinary and normal conditions these impressions are received in orderly succession, not in the heterogeneous jumble encouraged by the artificialities of modern life. This overstimulation is not confined to children of one class but is distributed throughout the various strata of society. If any escape it is, contrary to the popular impression, the children of the very rich. These, leading comparatively secluded lives with regular routine of sleeping, eating and exercise, are not subject to many of the dangers to which other children are exposed. "The poor little rich girl" or boy, misses many of the pleasures of childhood, but enjoys advantages which, if continued, as unfortunately is seldom the case, through adolescence and youth, would go far toward future physical and mental stability. It is in the families of average circumstances, the artisan, clerk and others of moderate incomes and in those of the small waged working man that the sins of commission and omission are most common. The overtaxed mother has not the time, and usually, not the knowledge of child training and child hygiene to insure the administration of those hygienic and disciplinary measures necessary to uniform development. Amusement for the adults in such families is impossible without the children sharing it, so even the youngest baby is taken to the movies, on long excursions and in various other ways subjected to physical and nervous exhaustion. Cannon, Crile and others have shown the results of exhaustion from various over-active sensory and emotional stimuli. I feel confident that the frequent exhaustions to which most children are subjected are a potent cause of nervous and mental instability. When there exists the added factor of insufficient diet the danger is increased.

The nutritional needs of the growing child are very generally underestimated. He requires food for the threefold purposes of growth, of utilizable energy, and for storage for future and emergency needs. In undernourishment the nervous system suffers first and most severely. The average child's breakfast is a hurried and haphazard affair, often among the poorer classes consisting only of "coffee soup," a large cup of warmed-over coffee into which chunks

of bread are broken. Within an hour or so the economy cries out for more nourishment and is quieted by a "piece" or by confections of doubtful purity and digestibility; as a result the child comes to the lunch table with impaired appetite which is assauged by an amount of food insufficient in quantity and quality. Again in an hour or two, starved tissues demand more pabulum. As a consequence the child's nutritional needs are inadequately met and disproportionately large amounts of carbohydrates lead to hyperactivity and muscular and neural exhaustion. A healthy child of six or seven years can easily dispose of a daily diet, properly balanced as to proteids, fats and carbohydrates, containing two thousand, five hundred calories. This amount is considered sufficient for an adult of sedentry occupation. Three thousand five hundred to five thousand calories is not too large an allowance for a child approaching or undergoing adolescence. I would emphasize the fact that these constitutionally unstable children often present characteristics similar to those of the high-grade feeble-minded, and diagnosis must often be deferred until the proper corrective measures, hygienic and educational have been applied.

Those Retarded Because of Physical Defects Which Can Either be Counteracted or Removed.—Among the physical conditions which lead to individual instances of retardation in mental development so serious as to lead to a suspicion of feeble-mindedness, may be mentioned; adenoids and enlarged tonsils, impaired vision due to errors of refraction, defective hearing and malnutrition. These conditions are common in the type of individual which I am accustomed to designate as hypoplastic, that is, the organically inferior with deficient potentials of correlative growth energy, the physically insufficient. In fact, these conditions, like nervous instability, are manifestations of the inferior organization, rather than the causes, and our diagnosis must often be in doubt until after corrective measures have been tried.

Treatment.—With, possibly, few exceptions all mental defectives are improvable, some to a slight extent only, others to an extent that renders social adjustment possible. Some of you are doubtless familiar with instances in which individuals, apparently feeble-minded in childhood, have by the subjection to a proper environment, become self-supporting and as well able to direct their own affairs as many of their supposedly normal fellows. Whether these cases

should, properly, ever have been considered true mental defectives or whether the psychologist would still find defects of mentality which would classify them as abnormal is not pertinent to this discussion. Most of us manage to exist fairly comfortably in the possession of defects which if discovered by the psychological enthusiast would immediately consign us to an institution. No one, who has given the subject any thought, will deny that to achieve success as a farmer requires a considerable amount not only of general intelligence, but of will power, reasoning, and executive ability as well. Yet Wallin, in investigating the reaction of successful members of the general population to the Binet tests, found that it is possible for a man to acquire a competency as a farmer and business man, to fill the presidency of the board of education in a small town, conduct a Sunday school, sit as director on the board of a bank, raise a family of nine children, all high-school graduates and all but one with college and university educations, all but three following professional pursuits, two holding assistant professorships in colleges, though by the Binet scale, his mental age is but 10.6 years. "This man measured by the automatic standards which have been commonly followed, would be hopelessly feeble-minded." [14] Yet who would say that this man should have been committed to an institution or restrained from propragation. I venture to state that even lower ratings than this would be found among artisans, laborers, and others whose economic value to the community is considerable.

I have already mentioned my own observations of the improvement following the administration of proper hygienic measures; fresh air, good food, regular hours, exercise, etc., as shown by the condition of boys committed through the Juvenile Court to a well-conducted institution. As has been stated, many of these boys, as a result of the initial examination, were thought to be feeble-minded, some being considerably below the accepted three year limit of retardation, besides presenting characteristics of physical constitution and behavior which stamp them as of the inherently defective class. Later examinations, however, showed a general improvement sufficient to render their status comparable to that of other boys whose normality had never been questioned. If such results follow the general appli-

[14] J. E. W. Wallin, "Problems of Subnormality," p. 223.

cation of hygienic measures, aided by educational, industrial and other training, the results from more intensive treatment should be even more satisfactory. That this is true, I have adequately proved to my own satisfaction in private practice.

It has been more or less the custom to cater only to the physical needs of the feeble-minded up until the age of six or seven years, which is considered early enough to begin the application of special educational measures. I think that this is a serious mistake and that this custom has been responsible for many human derelicts who might otherwise have lived lives of at least moderate usefulness.

Treatment should be begun as soon as the child's condition is recognizable as one of possible deviation. It is not necessary to wait until stereotyped tests can be applied. If doubt exists give the child the benefit of the doubt by treating him as a potential defective. If not defective he will be all the better for the treatment he has received. Even in early infancy there exist manifestations demanding attention. The undersized, puny, asthenic baby is not merely a problem of milk formulæ, for it is not so much the milk that is at fault as the physical organization of the child. Defects of correlative growth and subnormal activity of vital forces demand stimulation. Under ordinary circumstances the factors included in the term nurture are sufficient, but here not only must nurture receive unusual attention, but must be supplemented through the entire period of infancy and childhood. Gastrointestinal disturbances must be avoided as these occur with unusual frequency in this class of cases. Maternal nursing is highly desirable, but should be discontinued if conditions are unfavorable. The subnormal energy potential of the child is in many cases due to a like deficiency in the maternal organism, with consequent imbalance of other of her physiological functions including that of lactation. Through artificial feeding, certain principles essential to growth (vitamines, etc.) may be supplied which would otherwise be lacking. In some cases treatment of the mother by glandular therapy will insure an adequate and properly constituted supply of milk. Sajous,[15] advocates the administration of organic products to the mother during preg-

[15] "Our Duty to the Mental Defectives of the Present Generation," *New York Medical Journal*, April 1, 1916.

nancy when, because of poor heredity or constitutional inferiority, there is reason to suspect that the offspring may be defective.

Further on I shall take up the discussion of organotherapy at greater length. There is a tendency particularly among people who depend for guidance upon the popular books on infant feeding and the baby departments of the magazines to postpone unduly the time of giving foods other than milk, and to give foods in insufficient quantities, thus depriving the child of important physio-chemical substances at the time when they are most needed. The eruption of the teeth, Nature's method of indicating when chewable foods are needed, is a safe guide.

It is hardly necessary to speak of the value of fresh air as a factor in growth. Fresh air is not simply a vehicle for oxygen.[16] It exerts its beneficial influences through stimulating the peripheral nerve endings and thus activating all physiological functions, consequently the defective child should spend but a minimum of time indoors, but should eat, sleep and live in the open air.

Massage is useful as a form of passive exercise in children of deficient psychomotor control and when combined with corrective exercises is a valuable aid in the correction of spasticity, flaccidity, contractions, hypotonicity, etc. The general physiological effects of exercise are too well known to require enumeration, but this valuable remedy is neglected at the very time when it is of the most use. The very simplicity of the remedy leads to its under-valuation. Attention focussed too closely upon exercise in psychomotor development results in neglect of its other function, particularly at the age when most effective. There are none of the measures mentioned above which cannot be initiated in infancy.

Medical Treatment.—There is a prevalent impression that purely medical and surgical measures are of doubtful value in the treatment of the defective classes. While there is no known medical specific for defective development, yet the armamentarium of the physician and surgeon offers much that may be utilized. The beneficial effects of the removal of reflex sources of irritation such as arise from adenoids and diseased tonsils, eye strain, phimosis, impacted cerumen, carious, impacted and abscessed teeth, etc., are recognized.

[16] Fresh Air in the "Light of Recent Research on Ventilation," by C. E. A. Winslow, Chairman, New York State Commission.

A surgical measure whose value, is not yet sufficiently recognized is that of cranial decompression as practiced by Dr. William Sharpe, of New York. To most, any mention of head-surgery in connection with mental defectives brings up the idea of the old operation of craniectomy, of trephining, which differs radically from Sharpe's method. This again is a measure which should be applied as early as possible even within a few hours after birth.

In those cases of mental defect in which the presence of congenital syphilis can be demonstrated, even when it would seem to be the important etiological factor, anti-luetic treatment does not have the effects upon developmment that one might expect, in spite of this treatment should be continued until no doubt exists as to the eradication of the disease, in hope of at least preventing further degeneration.

It is now generally conceded that the chain of ductless glands is of the greatest importance in the development of the cerebrospinal and osseous systems in early life, and that impairment of functions of one or another of these glands underlies the disorders of nutrition which inhibit proper development. Under the caption, The Ductless Glands and Constitution, Falta says, "we must not accept the ductless glandular system for itself alone, but must regard it as a constitutional component; the ductless glands as vegetative organs together with the nervous system regulating their functions." While our knowledge of the normal action of these glands is still somewhat hazy, yet they are found to preside, in some manner, over certain correlations of the body. These correlations are exceedingly variable, and this variability is most apparent when and where circumstances are abnormal. The adjusting mechanisms of development are more or less reciprocal thus a ductless gland not only influences development, but is itself influenced by changes in general development. There is reason to suppose that in the harmony produced through the concerted action of the ductless glands, the leading rôle is played by the thyroid, which supplies the stimulus for bodily metabolism. As a check upon the influence of the thyroid in infancy and childhood, the thymus, the general lymphatic system, and perhaps the pineal gland, become active. In addition, these produce that delay of sexual activity which is essential to the proper maturation and stability of the somatic functions. In due time the adrenal system stimulates the sexual organs

to activity, and hastens as well the growth of the muscular and skeletal systems. Of great importance at this time is the action of the pituitary body, which stimulates every organ of the body.

Belief in the important rôle played by the ductless glandular system in development, and belief in the possibility of correction of developmental defects by measures calculated to stimulate or alter the action of the various component parts of the ductless glandular system, does not necessarily imply that all such treatment should be through the administration of ductless gland substances. There is not one of the measures already mentioned in connection with treatment which is without its effect upon the ductless glandular system, either as a stimulus to function or as a stabilizing influence upon the system as a whole. There exists a misconception which is fairly prevalent regarding the possibilities and limitations of organotherapy in the treatment of defectives. Those who are looking for a panacea of a specific will be disappointed. There are undoubtedly cases in which brilliant results follow the administration of organic substances, as thyroid in cretinoid conditions, anterior pituitary gland in distrophia adiposia sexualis, the whole pituitary gland, and thymus in certain types of infantilism, but these more conspicuous instances are the exception, as in most cases the implication is pluriglandular rather than mono-glandular and is a part of a general hypoplastic condition rather than a clinical entity. For this reason the best results may often be obtained by a judicious combination of the glands of internal secretion. When so used their effect is stimulation of all physiological processes.

EDUCATIONAL TRAINING

While certain refinements of application have been added, the modern methods of education as applied to the feeble-minded are essentially the same as those outlined by Sequin seventy years ago. Sequin emphasized the fact that "the physiological education of the senses must precede the physical education of the mind." Thus sensory training with its amplification into the training of the muscular system to ready and regulated response, must pave the way for more specific, intellectual training. The feeble-minded child is peculiarly incapable of abstract comprehension, and for this reason, instruction must be presented to it in concrete form. Whereas, the

normal child teaches himself through the exercise of his own spontaneous activity, the feeble-minded, the apathetic type especially, must be stimulated to action through encouragement, suggestion, and imitation. "Our system of education, then starts on physiological lines, first addressing itself to the *culture of the external senses,* then to the *coördination of muscular movement,* and finally to the promotion, by imitation and other exercises, both of the *manual and mental* activities." [17]

Many feeble-minded individuals are the possessors of excellent memories and these are capable of considerable progress along scholastic lines. Some have shown such extraordinary attitude along special lines as to merit the French appellation "idiots savants." Thus Tredgold[18] mentions a feeble-minded man in Earlswood Asylum whose penchant is biographical history, "It is only necessary to mention to him the name of any prominent personage in early or ancient history, and out there flows in a steady unhesitating stream a full and detailed account of his birth, life and death. His knowledge has been acquired by poring over biographical details in such books as were available, and is, of course, simply a matter of memory." Langdon Down[19] speaks of a boy having once read a book could ever after remember it. Doctor Down says, "I once gave him Gibbon's 'Rise and Fall of the Roman Empire' to read. This he did, and on reading the third page, he skipped a line, found out his mistake and retraced his steps; ever after, when reciting from memory the stately periods of Gibbon, he would, on coming to the third page, skip the line and go back and correct the error with as much regularity as if it had been part of the regular text." I, myself, had under my care at one time a feeble-minded boy whose memory for figures was truly remarkable, considering his limitations in other directions. He would repeat correctly after an interval of days a series of figures each composed of nine digits and could add a series of equal length as rapidly as they could be given him. He also possessed the ability to read

[17] Shuttleworth and Potts, "Mentally Deficient Children," 4th ed., p. 187.

[18] A. F. Tredgold, "Mental Deficiency," p. 272.

[19] J. Langdon Down, "Mental Affections of Childhood and Youth," London, 1887, p. 100.

a newspaper upside down as rapidly as the average person with the paper in the usual position. The higher grades of the feeble-minded are sometimes capable of absorbing considerable in the way of elementary education and a mastery of at least the rudiments of the three R's certainly enlarges their horizon, and is of no little assistance in the industrial training through which these individuals find their best method of expression. Every feeble-minded child has a right to the fullest education, scholastic and industrial, which he is capable of receiving, and while the process may be long, tedious and expensive, the results are sufficient to justify the means.

INSTITUTIONAL CARE

Industrial training can best be supplied in a suitable institution, public or private, for it is here only that he may compete on equal terms with his peers. In fact all training from the simplest sensori-motor up can be applied where the environment may be regulated to suit his needs without reference to companions of normal mental calibre. This is impossible in the home or the ordinary school. Many of the feeble-minded can be made productive under proper training and supervision, almost all can contribute their mite. In every well-ordered institution much of the labor of production is performed by the feeble-minded residents; they work in the field, in the dairy, in the kitchen, in the clothing and shoe factories, in the laundry and even in the printing room. Some of their handiwork in lace-making, rug weaving, carving, and basketry would do credit to skilled workers from the outside world. This under the supervision of trained directors, skilled in their various vocations and deep in their understanding of the feeble-mind, its simplicities, its intricities, and its eccentricities.

SOCIAL ASPECTS OF FEEBLE-MINDEDNESS

In the struggle for existence it is inevitable that those only will survive, in an economic sense, who are fitted by virtue of their mental, physical and social attributes for competitive supremacy. While the Declaration of Independence holds that "all men are created

equal," such statement should not be taken too literally. All of us are born with inherent limitations, or potentials, of mental and physical equipment which with the social *milieu* into which we are born determines our future failure or success. It is true that many because of superior capabilities are able to rise above the limiting effects of their immediate environment, but it is also true that many of us who complacently flatter ourselves that our success is due to our own superior mental equipment and to volitional effort owe our little attainments to the opportunities afforded us through the accident of birth. "There, but for the Grace of God, goes Samuel Johnson." Feeble-mindedness is one cause of social maladjustment and inefficiency, but it is one cause only, unless we interpret Tredgold's definition so liberally that social inefficiency *per se* constitutes the individual's inability "to perform his duties as a member of society in the position of life to which he is born." There have been many loose statements made apropos of the "menace of the feeble-minded." It has not been many years since I myself in the light of less experience in the study of the anomalies of human behavior made with considerable unction the trite statement "Every feeble-minded person is a potential criminal." This might with equal truth be said of the member of any class or type of the human family, and it might well be said of the feeble-minded that "Every feeble-minded person is a potential Saint." That the feeble-minded constitute a serious problem no one can gainsay but that the problem they present is any more serious than that of the nervously unstable and feebly inhibited, the tuberculous, the syphilitic, the sexually perverted and other classes of individuals, I am heretical enough to possess some doubt. I have already expressed my individual opinion regarding statistical computations concerning the feeble-minded, but in spite of their unavoidable fallacies such reports are the only means we have of estimation and while the actual number may be greater or less than they indicate, they give, at least, an idea of the magnitude of the problem. Kuhlmann, in a paper on "The Distribution of the Feeble-minded in Society," considers that a conservative estimate would place the relative frequency of feeble-mindedness in the general population at one per two hundred.

Of these there are in:

Institutions for Feeble-minded	4.5 per cent.
Reformatories	1.0 per cent.
Poor Houses	2.9 per cent.
Public Schools	40.0 per cent.
Unaccounted for	51.6 per cent.

The report of the Commission on the Segregation, Care and Treatment of Feeble-minded in Pennsylvania, made to the Legislature pursuant to joint resolution of June 14, 1911, places the number of mental defectives in that state as 15,000, six thousand of whom are either receiving institutional care or are applicants for such care, the remaining number, in the general population, whose presence is assumed "are to be found in classes for backward children at the public schools and also in the private schools. A larger number are in the reformatories, houses of refuge, jails and penitentiaries. Many are permanent residents of almshouses and work-houses; others are homeless vagrants. Probably, *by far the largest number are more or less self-supporting at some form of unskilled labor. Of this group comparatively few become delinquents, and thus come under the notice of the police authorities, or become dependents and get their names on the lists of charity organizations...Probably, by far the majority of the morons at large in the community are neither dependents nor delinquents, and under existing legislation not subject to committment for institutional care.*" (The italics are mine.) I will pass by the italicized extract of the report without comment other than to suggest that if to be more or less self-supporting at some form of unskilled labor, without dependency or delinquency constitutes feeble-mindedness, then the figures given are entirely too low.

It is when we come to selected groups, as of various types of delinquents and dependents that we acquire more specific and reliable information concerning the danger to the social body of the feeble-minded. Here the statistical evidence is more exact, based on more thorough investigation, as a rule by competent observers. The relations of feeble-mindedness to crime and pauperism is an intimate one. Of the inmates at New York Reformatory at Elmira, 37 per cent. are feeble-minded, of the New Jersey Reformatory for Women at Bedford, 37 per cent.; the Massachusetts Industrial School for

Girls, at Lancaster, 50 per cent., and the Maryland Industrial School for Girls, at Baltimore, 60 per cent.

Psychiatric examinations in connection with criminal, morals and domestic relations courts show a large proportion of feeble-mindedness though not so large as the unstable and feebly inhibited whom we may class as defective but not technically feeble-minded. There is no question but that defective individuals should be segregated, but segregation will never affect any but the more extreme cases. We must not forget that the social body is made up of individuals of different mental levels and that "hewers of wood and drawers of water" are necessary to the industrial efficiency upon which civilization rests. Thus the necessity for segregation must be based not so much upon the stage of development of the higher mental faculties as upon emotional control and inhibition.

HOW CAN THE DEATH-RATE FROM CANCER BE REDUCED?*

By POSTMASTER GENERAL HUBERT WORK, M.D.
President, American Medical Association, 1921-'22, Washington, D. C.

MR. PRESIDENT, Members of the Association, Ladies and Gentlemen:—If it should be made known that the President of the United States contemplated issuing an order for any public service, short of international war, which would cost annually ninety thousand lives, if millions of American women anxiously watched the massacre, terrorized by the thought that they too might be drawn into inevitable destruction, the loyal American people would rise in rebellion.

The casualties in the recent World War cost our people about eighty thousand men, less than the total number we annually see perish from cancer, as we stand helplessly by.

In the World War we all took willing part because our future protection was at stake. The war against the insidious destruction by cancer this Association is making, is less spectacular, but no less vital to our people.

It is a simple thing you are trying to accomplish and because it is so unselfish, so altruistic and is being so quietly prosecuted, it has not attracted the attention it should.

You promise no cures for the developed disease, because we at this time know of none, but the campaign of education being waged by this distinguished body, intended to familiarize people with the first symptoms of cancer, will eventually stand as a monument to the medical profession. You will be pleased to know that the American Medical Association, influenced in part by the intelligent insistence of your Association, is establishing a medical journal adapted to the lay mind, its purpose being to educate the general public so that through it the people may learn the signs of disease before they become signals that anyone might interpret.

In the list of preventable diseases, cancer will be given prominent place by this periodical and I am encouraged to believe that the

* An address delivered at Washington, D. C., April 25, 1922, before a public meeting of the American Society for the Control of Cancer.

self-denying labors of your Association will very soon bear more fruit, than in your discouraged moments, you have deemed possible, and that the world may soon know that incipient cancer, if early suspected and recognized, may be prevented.

The public knows that we can immunize the human being against many diseases heretofore regarded as self-limited only through death or recovery, and because of this knowledge, it is insistently urgent that we discover the cause of cancer and advise how to recognize its manifestations in time to obviate its fatal termination.

Medical men who are devoting their lives exclusively to this, notably the President of this Association, are in line to be knighted by the American people; to have their names recorded among public benefactors who also went about doing good.

The search for the cause of cancer is not restricted to the medical profession. Other scientists are equally impressed with the importance of such discovery, hoping therefrom to suggest remedies, once the cause has been demonstrated. Only yesterday, the Secretary of Agriculture came with a statement that a member of his research staff had discovered a growth in plant roots, which suggested to him the possibility of its relation to animal cancer. With the customary caution of a scientific man he did not even express a hope that something of value had been suggested, but his enthusiasm over the possibilities was unmistakable. For he too recognizes that the greatest pending world discovery is that which will lead to definite knowledge concerning this human destroyer. There are very few intelligent people in the United States who have not known someone whose life was destroyed by cancer, and there are many thousands who live in dread of its development in themselves. You may be sure of a sympathetic coöperation of the public in your endeavors in this direction, from this time on. I thank you.

THE CULTIVATION OF MEDICINAL PLANTS

A SUMMARY OF MANY YEARS OF EXPERIMENTAL AND FIELD WORK

By HENRY KRAEMER, PH.D.

Chairman, Subcommittee on Botany and Pharmacology, U. S. Pharmacopœia Revision Committee, Mt. Clemens, Michigan

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In the practical development of industry and commerce, there are two viewpoints, and there are necessarily two classes of students. Those in the one group consider only what is established and demonstrated by previous experience. In the second, much smaller group we find those who venture ahead of present-day practices.

During times of peace, the capitalist keeps pretty close to the shore-line of conservatism. He listens only to that inventor or originator who has demonstrated peradventure the practicability and plausibility of a project. It is in time of war that the resourcefulness of a nation means victory for her armies; then it is that the men of initiative, the experimenters along original lines, are called in for assistance. The efficiency of the enemy must be met by higher efficiency if victory is to be won. As soon as a problem is announced it must be solved to avert destruction. During the war we saw how gas offensive was met by an equal defensive, followed almost overnight by a higher offensive which spelt final disaster to the foe. The whole story of the ingenuity displayed by the Allies has not reached us, but we do know that the war changed the conservatism which is ordinarily displayed into a spirit of venturesomeness which has never been surpassed. Natural resources were developed in a spectacular fashion. Nature's forces were harnessed in an almost superhuman manner, and human efforts were coördinated in unity of purpose to a degree which no one would have prophesied.

The war showed, furthermore, that that nation that had command of the largest quantity of raw material, or that could synthetically reproduce it, would win the contest. The enemy found that if the nitrates of Chili were denied her, she must develop processes to derive them from the air; and if the cotton of the United States could not reach her, she must manufacture the supply from her forests. In the same way we found that if we could not obtain potash from the

mines which formerly supplied us, we must either discover new sources in nature or devise special processes for the recovery of this element. In the case of lubricants, where the shipments from other countries were slow and uncertain, the Government did not hesitate to plant thousands of acres of the castor-oil plant, which would give us an independent harvest. Probably the most remarkable industrial achievement during the war was the production of the inert gas helium, used in balloon work, at a cost of ten cents per cubic foot, when the pre-war price was about $1750 per cubic foot. At each point, lack of supply was met by a high order of resourcefulness, which made for productivity equal to the needs required. Those who have any knowledge of the situation which confronted us at the time of our entry into the war, knowing how each need was met on a fairly lavish scale, will no doubt be willing to admit that with regard to the materials necessary for carrying on the war we were prepared to meet every exigency. In connection with this development new industries were created, and some which had been experimental in the past were established on a commercial basis. Among the newer phases of activity thus developed, none was of greater interest than our ability, independently, to produce and manufacture the medicines which were deemed necessary by our army.

One of the most fundamental questions, which we must consider immediately, is to what extent we should relinquish the vantage-point we have attained and go back to our pre-war practice of depending on foreign countries for not only raw but manufactured materials as well. I may not be a prophet, but I have sufficient optimism to believe that the old dependent conditions will not prevail and that manufacturers realize that in the interest of our country we must be more independent of other nations. At the present time and with things in an unsettled condition, trade and industry and large projects are not being undertaken to any extent. I have seen figures of contemplated improvements and various projected enterprises of such a gigantic character that I feel that we are approaching a new era in which the pioneer will work with the capitalist and in which a truly rational condition will prevail.

For some years now I have felt that it was desirable for us to cultivate very many, if not all, of the really important medicinal plants. This principle is sound and tenable, in the interest of

uniformity of drugs and progress in the action of medicines. Furthermore, our supplies are becoming depleted and in some cases are almost even now exterminated. It is important that we understand the extent of the problem and the object to be attained in order that we may attack it in an effective manner. I think that it is largely due to our lack of perspective that we have not made greater progress. Of course, it is always necessary in a new venture to make a demonstration of facts to support the thesis.

I have called attention (*American Journal of Pharmacy,* 1918, vol. No. 80, pp. 404–415) to what was accomplished during the war. What may further be undertaken can be determined only by experiment. The history of the cultivation of plants yielding industrial products is rather anomalous. For instance, there are certain plant products which it may seem for the moment are confined to certain geographical centres, as the growing of cinchona, rubber, coffee, and spices. Yet even these are being more widely grown constantly for commercial reasons, and at present it is rather difficult to tell just which countries are producing our commercial supplies. The original home of cinchona was in South America, and it is only recently that any attempt has been made to restore this industry to this part of the world. Furthermore, were we dependent upon the native cinchona tree of South America for our source of supply of quinine, this alkaloid would be not only of prohibitive price, but so rare as to make it a museum specimen. This would be a dire calamity, as quinine is one of the alkaloids that would be exceedingly difficult for us to make synthetically at a fairly reasonable price. All of the commercial cinchona is obtained from trees cultivated in the East Indies, British Indies, Mexico and Northwest Africa, and there is just a possibility that it might be cultivated in certain parts of California. Coffee, originally of Abyssinia, and at one time almost solely cultivated in the East Indies, is now an important article of export from South America, Brazil sending us not less than 600,000 tons annually. The spices trade, originally confined to the Dutch East Indies, has been extended to the West Indies and other tropical countries. Until the last edition of the U. S. Pharmacopœia (1916) Cannabis Indica was derived solely from plants cultivated in India. The Indian Government placed an export duty upon this product, and in a remarkably short time we were importing a high-grade drug

from Africa, Asia Minor, Turkestan, France, Italy, Spain, Mexico, and almost simultaneously we found that we could grow an exceptionally active drug in the United States.

Many drug-yielding plants are used also in other industries and often in greater quantities than in their medicinal use. For instance, some of these, as Cannabis, furnish stems which are of considerable value, yielding, as you know, the hemp fibre. The "braking of the hemp" was at one time practiced in Michigan, and there is apparently no reason why the product here should not be equal in quality and value to that product in Kentucky. Again, there are the poppy capsules, which yield an abundance of an oily seed used in baking. The lavender flowers and marigold plants can be made into a fragrant potpourri, etc.

The interest in the cultivation of medicinal and economic plants began with the early settlers. Hops may be considered the first medicinal plant to be grown in the United States. It was first grown in Virginia, but with very poor success. Later it was found that a colder climate was better suited for the growth of the hop plant, and the cultivation was taken up by some of the farmers in New England. It was then introduced into New York State and later spread into Michigan and some of the other Middle and Western States. It is from these states that our commercial supplies are chiefly obtained.

It is not always easy to determine what plants can be successfully grown in any given locality. Actual field tests only can give the correct data. Failure, while it has a practical significance, acts only as a stimulus to the pioneer. There are indeed very few plants that have not become established in other localities than those in which they are indigenous. One of these is the Venus' Fly-trap, which has not been successfully established outside of its home in the vicinity of Wilmington, North Carolina.

The experiments with the hop plant have been duplicated with other plants, especially those of the Mint family. The peppermint industry was first developed in Wayne County, New York, and later taken up in Michigan, Indiana, Ohio, and other states. By reason of the more favorable climate and soil conditions, the peppermint industry in Michigan has outstripped that of the other states. The total amount of peppermint and spearmint oil produced annually

throughout the world is about 600,000 pounds. At the present time nearly one-half of this is produced in the United States, Michigan producing the largest proportion. It is not merely due to the fact that the muck lands of Southern Michigan are especially suited to the development of these labiate plants, but also to the fact that the growers in Michigan have invested considerable capital in the business and have provided themselves with an equipment which enables them to handle the distilled oils in an economical manner. The cost of operating an acre of mint and caring for it during the first season is placed at about thirty dollars. This is cut about one-half in subsequent years. The yield of green herb is about 30,000 pounds per acre, and this will give on distillation under the most favorable conditions about 100 pounds of oil, which will bring about two hundred and fifty dollars in the trade.

In Ecclesiasticus (38:4) it is written that "The Lord created healing herbs out of the earth and a prudent man will not cast them aside." The origin of the use of medicine goes back to antiquity, and there are records which show that some of the important medicinal plants were cultivated since first their value was known. With the exception of the important farm products there have been but comparatively few plants cultivated for medicinal and industrial uses. Throughout the world nearly all of our crude drugs and the commercial supplies of very many economical products are still obtained from wild plants. From the fields and forests of the United States enormous quantities of useful products are obtained. It would be rather difficult to give an exact computation, but somewhere from 25 to 50 per cent. of the raw material used in the arts and medicine are derived from plants growing in our country. The remaining supplies are imported from nearly every part of the world. It may be too much to expect that we can ever become entirely independent of all other countries for our raw materials, but the lesson of this war teaches us that we should take every precaution to provide against our being too dependent, and thus seriously handicapped when for any reason these foreign supplies are cut off. This situation would be greatly improved by mutual agreement with other nations to the exchange of drug materials. History shows that monopolies of medicinal supplies often give rise to prohibitive prices, much to the discomfiture of the trade and greatly to the detriment of the public.

Some thirty-five years ago an effort was made to have the United States Department of Agriculture carry on experiments which would ultimately lead to the introduction and cultivation of very many foreign medicinal plants. It was not, however, until 1913 that the reorganization of the Bureau of Plant Industry of the United States Department of Agriculture instituted a special department for the study of drug-yielding plants. This department has since then conducted experiments on a number of both native and foreign drug-yielding plants. There has been a divided opinion in this country as to the possibility of cultivating medicinal plants and placing this industry on a paying basis; in fact, there has been a prejudice against seriously considering this subject in a practical manner. No doubt some of this sentiment was started in the interest of those who were exporting drugs to this country. Fortunately, however, some ten or twenty years ago there were those who recognized that our supplies of native plants were being reduced as well as becoming of inferior quality, and attention was directed to the necessity of providing for future supplies through drug farming. Of course, sporadic attempts had been made to grow medicinal plants in this country; but, with the exception of ginseng, the attempts could hardly be termed successful. Valerian was grown in Vermont, licorice in New Jersey, saffron near Lebanon, Pennsylvania, but these efforts were of hardly more than local interest. Mrs. Gene Stratton Porter's book on "The Harvester" appeared at a psychological moment, and to a remarkable degree influenced business men to consider seriously this question. In the meanwhile, experiments had been conducted which showed that cultivated plants were, if anything, more efficient than wild plants, and with the acceptance of this theory a few manufacturers were ready to farm a certain number of medicinal plants. The war situation brought us face to face with a possible scarcity of a number of valuable crude drugs, and with the experience which we have been gaining we have been rapidly building up this new industry. The question which is giving me some concern is, will we continue under normal conditions to develop this industry, or will we allow it to lapse, losing the impetus which we have thus far acquired, leaving it to another generation to work it all over again?

The greatest obstacle in our developing drug farms has been the high price paid for labor in this country, and the fact that we did

not know how to grow medicinal plants and harvest them so as to meet the foreign conditions where low-price labor prevails. Since the war many of the foreign sources for crude drugs have been cut off, and the prices soared so high as to make the cultivation of several medicinal plants very profitable. Indeed, it has been possible to raise crops valued at from one hundred to one thousand dollars per acre. It is quite likely within the next year or two that we will again be supplied with foreign drugs or they will be offered for sale, and the question will be whether we can grow and harvest our own drug-yielding plants and market them at a price to compete with those obtained from foreign sources. It is quite likely that a number of those who have started drug farms will be discouraged, as the market prices for crude drugs will come down from 50 to 75 per cent. In other words, the prices will approach more nearly normal conditions. There are two things necessary to make drug farming a success in the United States. The first is, that the most economical conditions must be worked out for growing the plant and harvesting the drug. The second is, that sufficiently large farms must be developed so as to make it profitable for the farmer. The profits in most cases, no doubt, will be greater than in ordinary truck or produce farming, but the permanent returns cannot be expected to compare with those which prevail at present.

Some 20,000 medicinal plants, representing more than fifty different species, were grown by the author at Ann Arbor during the summer of 1918. Notwithstanding all of the difficulties that naturally beset such an experiment in its early stages, including the great variations in seeds and the difficulty of securing labor, the loss of plants was so small as to be practically negligible, and the crops from nearly 15,000 plants were harvested, the remainder being left in the field. The facilities for drying such large quantities of material were inadequate, and the floors of the lecture and laboratory rooms of the Science Building and the attic or loft of the Chemical Building had to be utilized for drying the crop.

Of all who have written upon the subject of the cultivation of medicinal plants in this country, almost no one has had the vision to see the possibilities of this new industry, and for the most part all efforts have been directed toward discouraging rather than encouraging the enterprise. One of the chief objections which have

been raised is that the amount of drugs used is so small compared to the enormous amounts of foodstuffs. For instance, it is estimated that the amount of belladonna which would be used in the United States could be grown on about three hundred acres. While this limitation may be true of quite a number of our medicinal plants, yet it must also be borne in mind that some of these drug-yielding plants have very great uses outside of the medicinal one. As an illustration of this we may refer to the castor-oil plant, the seeds of which yield a fixed oil commonly known as castor-oil. It would seem reasonable that the output from five hundred acres should yield all the castor-oil which is used in medicine in the United States. But its uses in this manner are infinitesimal compared to its use as a lubricant for fine machinery. During normal times we import over one million bushels of castor beans per year, the oil being extracted by vegetable-oil crushers in the United States. So dependent was our Government during the last year of the war on the supply of castor-oil as a lubricant for the motors of aeroplanes that it made arrangements in the Southern States for the planting of one hundred thousand acres of the castor-oil plant. The problem with this industry is not one, then, of small acreage, but of placing it on a basis to compete with the lower cost of labor in India. In fact, even at the present time the oil-crushing interests of the United States have taken steps to see that the Government develops a post-war policy which will not place the American crushers at a serious disadvantage.

With the advent of every new problem there are, fortunately, a few who are willing to venture and to have faith in their experiments, but there are also a great many good-intentioned people who are unable to see what has not as yet been demonstrated. Many of them are like the man who sees the forest at a distance; to him it seems like an adamantine wall, and, unfortunately, he never gets close enough to see the path which lies between the individual trees. It is the man who gets right down to the problem that sees the light and makes the clearing and does something for humanity. It reminds me of the days of Watt. When he was introducing the steam-engine some one suggested, "What if a cow should get on the track?" To this he serenely replied, "It would be bad for the cow." In addition to some of the objections already pointed out there are those who fear that there is sure to be an over-production of some one crop and

that this will be followed by a lot of attending evils. The man who is intelligent enough to farm medicinal plants is likely to possess sound judgment. The farmer who is growing a hundred acres of corn to-day is not likely to plant another hundred in sweet marjoram, or dill, or some other crop which is used as a potherb. In other words, these matters will all right themselves, and possibly even new industries may develop as a result of this over-production. The fact is, if we can get the pioneer on the soil of opportunity, he will develop it to its utmost, as was done in the case of the peppermint industry.

No one ought to engage in the work of cultivating medicinal plants without consulting those who can give him some information as to the probable quantities of drugs that may be required. Unfortunately, statistics are not easily procurable, and I have never been able to satisfy myself as to the quantities of any one drug that are annually used, but drug-dealers will supply information as to market conditions as probable needs at any one time. I, however, think that the greatest danger does not lie in the over-production. Some mistakes will doubtless be made, but the mistakes of wrong decision in this matter will not equal those of indecision, which is very vital at this time. The assuming of a negative attitude or a "do-nothing" position on this subject means the dwarfing and killing of the whole problem, unless the antagonism may put those who are giving the subject consideration on their mettle. The fact is, however, there are so many practical problems that require attention that we need all the constructive thought possible. The first question that should be answered is, "Why is it necessary to grow medicinal plants?" The principal reason is one which is seldom emphasized or taken into consideration. We ought to grow drug-yielding plants in order that we can obtain drugs of uniform quality. At the present time any lot of drugs may represent the work of a great many unskilled collectors, situated at widely different points and collecting at widely different seasons. The only way that this can be avoided is to establish farms where the drugs can be harvested under competent direction, assaying the material so as to check up its real medicinal value. It is almost self-evident that we never will secure drugs of uniform quality unless they are derived from plants developed under control and which have been grown from seed the origin and nature of which is known.

A second reason for growing medicinal plants, which is usually given precedence, is that the amount of active principles be increased. If plants are kept under surveillance and the experiments conducted under scientific management, this increase in active principles is sure to follow; for by selection and conservation of the seed, plants particularly rich in active principles will continue to be propagated. Ultimately drug products, like farm products, will represent the sum of experience and include only those desirable varieties of the highest grade.

The third reason that is usually given for taking up the cultivation of medicinal plants is that our drug supplies, and that applies especially to native drugs, are becoming scarce. In fact, very many of them, as ginseng, pinkroot, male fern, and others are pretty nearly exterminated. For this reason alone it is only a matter of a few years, if drugs are to be used at all, our supplies must of a necessity come from plants under cultivation. Of course, not all plants used in medicine can be intensively cultivated. Of the 10,000 plants used in medicine in all parts of the world, probably not more than 10 per cent. are of permanent value.

In order to succeed in drug farming there are two mighty important questions that need to be answered to put this industry on a paying basis. The first of these relates to the growth of seedlings. In Michigan, and in most places where experiments have been conducted, it is necessary to germinate the seeds in greenhouses or cold frames and to transplant the seedlings to the field. As most seeds require from four to eight weeks for germination and an equal time is necessary for them to get fairly well established, it is apparent that by starting them in the greenhouse we save four to five months of time. But this requires a great deal of space and consumes a great deal of fuel, as the preliminary steps are taken in January and continued during the coldest weather. Then, too, considerable labor is required in transplanting these seedlings from the seed-pans to the flower-pots and from the greenhouse to the cold frame. If they could be sown directly in the open and brought to maturity before the cold weather of autumn, there could be a considerable saving of expense and labor. The experiments conducted here last summer show that many plants can be grown in the open, but the crop will only be from 10 per cent. to 20 per cent. compared to that obtained from plants

previously started in the greenhouse. Therefore, one of the first problems is to obtain seed which will germinate rather quickly and at relatively low temperatures and which will run through the vegetative period rather quickly.

Then, again, we need to know more in regard to soil conditions and the use of fertilizers. Some of them increase the growth of the plants, giving vigorous stems but less leaf area and root production. In other words, growth is at the expense of the active principles, and the increase is really a loss rather than a benefit. During the past year we have not utilized any fertilizer, and yet the plants have been excessively high in active principles. There can be no question but the judicious use of fertilizers will help to improve the quality as well as yield of drug. As a general rule, a well-rotted barnyard manure seems to be the best for general applications. Next to this a mixed fertilizer such as ordinarily used on farms gives excellent results, provided it is worked well into the furrows. Hand in hand with the subject of fertilizers goes the subject of cultivation. In most cases weeds and other farm plants should be excluded, but there are doubtless many instances, as in the case of woodland plants, which are shade-loving, in which a mixture or society of plants would prove beneficial. This would especially apply to plants like ginseng, goldenseal, mandrake, and others of this type. Many of the experiments which have been made seem to show that continuous sunshine, especially when accompanied with hot and dry weather, is detrimental to the growth of the plants. This, however, has not been my experience at the University of Michigan. Here the natural conditions seem to favor the best production and maximum yields, the plants withstanding even temperatures of 115° F. and prolonged drought.

Probably the most important phase of the economic production of drugs is the question of collecting and preparing them for the market. Nearly every one who has gone into this work has installed some special drying apparatus, usually employing a certain amount of heat. In the case of belladonna and digitalis, the leaves are separated from the plant, placed in separate layers on frames and dried, using artificial heat. This, again, is expensive, requiring considerable labor and drying facilities. If the stalks are strung on wires or spread in drying-sheds, and thus protected from rains and dews, there will be a great saving of labor and a much larger crop can be handled. This

latter plan was followed at the University of Michigan, and all of the plants thus far examined have shown an activity at least twice that of the official standards prescribed.

The number of medicinal plants which have been cultivated is exceedingly small, and the failure of attempts to cultivate a larger number is rather surprising in the light of the results which have been secured during the past season at the University of Michigan. The reason why so many plants were grown was because it was anticipated that about 90 per cent. or 95 per cent. of them would succumb in the course of the season. As it was, every plant, of which we had seed which would germinate, did well, even in the open.

The following is a list of plants which were grown by the writer at the University of Michigan Botanic Gardens. No attempt is made to distinguish between the really useful and those which might be considered by some to be unimportant. They all are used to some extent and have a market value.

(1.) *Althæa officinalis* (Marshmallow). A perennial herb with rose-colored flowers. It somewhat resembles the hollyhock, the plant flowering from July to September, the seeds following in little capsules or buttons. The whole plant is mucilaginous, but the root is the only part used in medicine in this country. The leaves and flowers are also used in Europe.

(2.) *Anethum graveolens* (Dill, Garden Dill). The plant resembles fennel, but is smaller. All parts are aromatic, the leaves being used chiefly as a flavoring for culinary purposes. The fruit is used to some extent in medicine, and the aromatic water produced therefrom is official in Great Britain, where it is used as a vehicle in medicine, closely resembling caraway water. The aromatic properties are due to an oil which is present to from 2 to 4 per cent. in the fruits.

(3.) *Anthemis tinctoria* (Yellow Chamomile). It is a low plant resembling the plants commonly known as chamomile, but with large yellow ray flowers. It is occasionally employed in Europe as a tonic and vermifuge. Our great interest is in the fact that it is sometimes used as an adulterant of arnica flowers and is to be distinguished only by the fact that arnica has a series of bristles at the summit of the achnes.

(4.) *Arctium Lappe* (Burdock). This is a common weed, and while at the present time it is not generally believed to have any medicinal value, the fluid extract is recognized by the National Formulary. The root as well as the leaves have been used as an alterative and in chronic skin diseases.

(5.) *Artemisia Absinthium* (Wormwood). No less than thirteen different species of Artemisia are used in medicine. As one would infer from the name wormwood, this plant is used as an anthelmintic. It is not much used at the present time, owing to the fact that there are other drugs, such as thymol, oil of chenopodium, santonin, and a few others having the same specific actions. There are, however, a great many valuable anthelmintics which have gone out of fashion because either of the inferiority of the drug on the market or its not

having been carefully investigated, and any one or all of them may come into vogue again. An infusion, as well as the volatile oil, of wormwood is used in medicine. The oil also enters into the liqueur known as absinthe, which, however, is debarred importation in the United States at the present time.

(6.) *Atropa Belladonna* (Deadly Nightshade). Almost all the parts of this plant, with the exception of the thick, woody main stem, are used in medicine. The roots, leaves, and young stems, with their flowers and fruits, are official in all of the pharmacopœias of the world. The plant is a native of Central and Southern Europe, and it is rather strange that it is not naturalized outside of these countries, although it has been reported as growing in Michigan. It grows vigorously under cultivation in England, France, and the United States. In countries where it is indigenous the seed can be sown in the open, but in other places it is necessary to start the plants in the greenhouse, the sowing usually being made by the first of February. Experiments, furthermore, conducted in the United States seem to show that the plant will not over-winter, and in order to secure large roots of the second- and third-year crops, the roots must be dug up before the advent of frost, carefully stored during the winter, and transplanted the following spring. (Fig. 1.)

(7.) *Atropa physaloides* (Apple of Peru, Peruvian Bluebell). This is a large herb with nodding blue flowers, and the specific name is derived from the Greek, meaning "bladder-like," alluding to the fruit being enclosed in an inflated calyx.

(8.) *Aquilegia vulgaris* (Garden Columbine). This plant is a native of Europe, cultivated in our gardens and naturalized especially in some of the Northern States. It was at one time used in medicine. The flowers have a great variety of shades, ranging from pink to blue, some even being white. They are also interesting because the petals are prolonged into large, hollow spurs, which are hooked, distinguishing them from the native columbine, the spurs of which are straight and the flowers of which are scarlet on the outer surface and yellow on the inner.

(9.) *Borago officinalis* (Borage, Star-flower). This is a European annual with a spreading five-parted blue corolla. The plants abound in mucilage and contain besides considerable potassium nitrate and other salts.

(10.) *Calendula officinalis* (Marigold). This is a plant of the cultivated gardens, but should not be confused with the French or African marigold, of which there are some beautiful double varieties, but which are an entirely different plant, being *Tagetes patula* and *Tagetes erecta*. For a long time a tincture made from the yellow florets was official. It is still retained in the National Formulary and used by the homœopathic physicians, who employ a rather excellent preparation made from the fresh florets.

(11.) *Cannabis sativa* and the *variety indicus* (East Indian Hemp or American Hemp). The stems yield on retting a fibre known as hemp; the fruit, or so-called seeds, are used as a food for birds; and the resinous tops are official in very many of the pharmacopœias. For years it was the *Cannabis* grown in the East Indies that was used in medicine throughout the world. Within the past few years the Indian Government has placed a high tax on every pound of the drug that is grown. The result has been that other supplies were sought, and it was found that the plant could be grown in other parts of the world, and to-day the hemp plant is cultivated in Asia, Africa, and the United States. At first the American drug did not seem to be of like quality, but by careful

selection and experimentation a drug has been obtainable from plants grown in the United States which is the equal of that formerly imported from India.

(12.) *Carum Carvi* (Caraway, Caraway Seed). The fruits of this plant are commonly added to cakes and bread to give them an agreeable taste. The fruits are also used in medicine, either in the form of an infusion or an aqueous distillate prepared from them, or a volatile oil, which is extracted. The latter contains thymol, which is a specific in the treatment of hookworm. The caraway plant is a biennial. The fruits are obtained, after it has been cut down and allowed to dry, by threshing the plant on a cloth. For some time back the market supplies have been obtained in part from an American-grown drug, though its fruits are usually somewhat smaller than those imported from Europe.

(13.) *Chenopodium Ambrosioides*, variety *anthelminticum* (American Wormseed). About the time that the importations of thymol were considerably lessened, it was very fortunately ascertained that oil of chenopodium was equally as efficient as thymol in the treatment of both hookworm and tapeworm. Indeed, at the present time it is considered, because of its efficiency, low toxicity, and ease of administration, the most valuable of all vermifuge remedies. There has also been a prevalent notion that the chenopodium plant could only be grown in certain parts of Maryland. It is true that the Maryland oil may be of a higher grade, but the oil distilled from plants grown at Ann Arbor show a remarkably high efficiency, and it is not at all unlikely that when we secure seeds of the best variety and properly understand the distillation, Michigan will be an important commercial source of the oil. The oil apparently is produced in hairs on the immature seeds, being held within a thin, bladdery fruit wall, which encases the whole. The wormseed plant is cut down and dried and the fruits are separated by means of threshing.

(14.) *Coix Lachryma-Jobi* (Job's Tears). This plant belongs to the grasses and is indigenous to the East Indies and Japan. The so-called seed is really a fruit, being nearly spherical, about one-quarter inch in diameter, shining, white, and very hard. It is sometimes used in the making of necklaces for teething children, the impression being that they will cut their teeth more easily. I suppose, however, that the children use it like orris-root or other hard substance, in rubbing it against the gums, thus facilitating teething.

(15.) *Conium Maculatum* (Poison Hemlock). The small fruits of this plant are said to have been used by the Athenians to destroy the life of condemned individuals. An infusion was used to kill Socrates and Phocion. It has been used as a medicine since very ancient times, the fruit and leaves both being used. It is a rather pretty plant, having large, decompound leaves and umbels of small white flowers. The fruits are gathered when full grown, but while still green. The leaves should be gathered at the time of the flowering of the plant, quickly dried, and carefully preserved.

(16.) *Datura meteloides.* This is a tropical species having all the appearances and properties of our common Jimson-weed. It is, however, a more robust plant, branching profusely and bearing very large white flowers. On account of its high yield of alkaloids it might profitably be hybridized with our native Jimson-weed. In fact, there are a great many tropical forms of Daturas which have been successfully cultivated and are used for decorative purposes. They are nearly all rich in alkaloids. Hardly any of these tropical species have become

naturalized, as the seeds apparently will not over-winter; but one of them, *Datura Metel*, is becoming somewhat frequent in waste ground.

(17.) *Datura Stramonium* and *Datura Tatula* (Jamestown or Jimson-weed). These are two rather common and rank weeds. The leaves and flowering branches are official. These plants are good examples of the desirability of cultivating even such common and widespread plants. The commercial drug varies very greatly in its alkaloidal content, and in cultivating it it is expected that desirable strains may be obtained, showing uniformly high activity. It has been found that the application of certain nitrogenous fertilizers will cause a perceptible increase in the amount of active principles. But this is not yet sufficient, so experiments are being conducted in this country with the view of increasing the alkaloidal content by selection of seeds.

(18.) *Digitalis purpurea* (Foxglove). This is one of the five most important drugs used in medicine, the others being opium, yielding morphine; cinchona, yielding quinine; iodine, and mercury and its salts. Under the name of *Digitalis gloxiniæflora* there are a number of horticultural varieties of *Digitalis purpurea* cultivated in the gardens. They are all more or less toxic. The form which produces purplish flowers that are more or less spotted is the one used in medicine. It is a biennial plant, producing flowers in the second year. In this country it has escaped to some extent from the garden, and in Oregon and Washington grows wild. Digitalis has been quite extensively cultivated in the United States during the past few years, and it is the work done in this country which has thrown considerable light on the nature of the drug and its constituents, as well as its physiological action. (Figs. 2 and 3.)

(19.) *Digitalis grandiflora.* This is a biennial or perennial plant with ovate lanceolate leaves and large yellowish flowers. The plant growing in Switzerland seems to be quite as efficient as the common foxglove. (Fig. 4.)

(20.) *Digitalis lanata.* This plant produces oblong or lanceolate leaves and rather small flowers, varying from a creamy yellow to a whitish or purplish color.

(21.) *Digitalis sibirica.* This may be only a form of Digitalis lanata, as the flowers closely resemble the latter species. Experiments are being conducted with these and several other species of Digitalis, besides purpurea, with the view of determining if one or more of them may not give with greater uniformity the heart-acting principle and possibly enable us to make a more permanent preparation.

(22.) *Grindelia squarrosa* (California Gum Plant). This plant is found on the prairies and dry banks of the Western States. On account of its scarcity it is being cultivated. It is commonly employed in the treatment of bronchial catarrhs. The plant is rather easily grown from seed and, if the cluster of radical leaves prove to be as efficient as the stem leaves and flowers of the second-year plant used at the present time, the drug on the market will be considerably improved.

(23.) *Helianthus annuus* (Sunflower). This plant is very extensively cultivated in China, Europe, and in the United States for the fixed oil obtained from the seeds, as much as 275 pounds of oil often being the yield per acre. In Russia the seeds are eaten the same as the Americans eat peanuts, and it is not uncommon to find the vender on the sidewalk with his tray of sunflower seeds. The pith is valuable as a source of cellulose, and the leaves are used by the people of the Caucasus in the treatment of malaria.

(24.) *Hyoscyamus niger* (Henbane). This species produces two forms, the one annual and the other biennial; in fact, it may be said to possess an alternating annual or biennial habit. Apart from its medicinal interest this would be one of the most interesting plants for the studying of the origin and nature of the biennial habit of many plants. For a time considerable difficulty was experienced in growing henbane in this country, but at present it is recognized that if the plants are subjected to severe cold, as 20° F., they will germinate readily. Indeed, in certain parts of the West, as in Oregon, the plant has become well established. It is also reported to be well established in Mackinac Island, in the Straits of Mackinac, between the two peninsulas of Michigan, and on the adjacent mainland on either side.

(25.) *Hyoscyamus niger*, variety *pallidus*. This is a plant resembling the annual henbane, but producing yellow flowers.

(26.) *Inula Helenium* (Elecampane). This is a perennial herb naturalized in Europe and growing in many places in the northern United States, sometimes occurring as far west as Missouri. It has considerable interest in medicine and is recognized in the National Formulary.

(27.) *Iris germanica* (Orris Root). This plant is a native of Italy and is cultivated in a number of countries bordering the Mediterranean. The commerce supplies are obtained chiefly from the neighborhood of Florence. It is chiefly used in the making of sachets and used in the perfuming of toilet preparations.

(28.) *Levisticum officinale* (Lovage). This is a branching perennial herb producing small greenish-yellow flowers which are followed by strongly aromatic fruits. The parts used in medicine are the roots and fruits. The plant contains an interesting coloring principle which may be used to identify limestone water. If the water is pure or neutral the principle gives it a crimson color, but if it is alkaline a blue color appears.

(29.) *Martynia proboscidea* (Unicorn Plant). This is a low plant with heart-shaped leaves and beautiful white or purplish spotted flowers. The fruit is terminated by a two-horned beak, causing some species growing in Mexico to be known by the name of Devil's-claw, in allusion to the clinging hooked fruits.

(30.) *Matricaria Chamomilla* (German Chamomile). There are two genera of the compositæ which furnish plants commonly known as chamomile. One of these is the genus *Anthemis*, which furnishes the garden or English chamomile. There is another plant of this genus *Anthemis Cotula*, which is very common and known as May-weed or Dog fennel. The latter plant looks like a daisy, and flowers throughout the summer. A plant resembling this is the *Matricaria Chamomilla*, but this is very sparingly naturalized. The German chamomile, which is official, comes to us from Germany, and is usually collected from wild plants. It is well worth cultivating it, as it has been commanding a price of fifty cents a pound. The flowers only are used in medicine, although all parts of the plant are valuable. It is chiefly used as a mild tonic, but is also useful as an anthelmintic. (Fig. 5.)

(31.) *Nepeta Cataria* (Catnip). This European plant is not infrequently found as a common weed near dwellings, having been introduced through its cultivation. It is used to some extent in medicine and is still recognized in the National Formulary. The name Catnip is given to it because of the fondness which cats show for it, either in the fresh or dried condition. The leaves and flowering tops are used in medicine.

FIG. 1.

Belladonna root. An unusually long tap root from a plant three years old. Belladonna root can be collected from first-year plants, the yield being from 500 to 1000 pounds of dried root per acre.

FIG. 2.

Digitalis purpurea. A clump of first-year leaves which are highly efficient in their physiological action, indeed surpassing the best imported drug. This is a great triumph in American drug culture as up to the experiments conducted in this country we were tied by tradition and our information came from foreign sources. To-day not only are we producing fine digitalis, but our chemical and pharmacological studies are of a high scientific order.

Fig. 3.

Flowers of digitalis. They are purplish and more or less spotted and the long racemes are among the most attractive of the garden.

FIG. 4.

Digitalis grandiflora. This species has been found to equal *Digitalis purpurea* in its physiological activity. The studies of digitalis in this country have shown that there are some species that are free from irritant and excitant properties. This is one of the several species upon which investigations are being made.

Fig. 5.

German chamomile plant. It is profuse in its flowers and the plant is easily cultivated.

Fig. 6.

Rheum palmatum, one of the plants which furnishes the official rhubarb.

FIG. 7.

Specimens of rhubarb root obtained from American-grown rhubarb plants.

Fig. 8.

Cypripedium pubescens, one of the species with yellow flowers which furnishes the drug which was formerly official.

(32.) *Nicotiana Tabacum* (Tobacco). Notwithstanding the fact that not less than 1,000,000 tons of tobacco are used annually for smoking and chewing purposes, a small quantity is used in medicine. In fact, the oil of tobacco was at one time official, and was extensively used during the early and middle parts of the last century. There are a number of varieties of *Nicotiana Tabacum* which are cultivated; we have had the Pennsylvania and the Havana varieties in cultivation. These two forms resemble each other, but the Havana form has more ovate leaves and dark pink flowers. The value of tobacco depends on its being properly cured and prepared for market.

(33.) *Ocinum Basilicum* (Sweet Basil). An annual herb commonly cultivated as a seasoning, but having also the medicinal properties of other mints. It yields an interesting oil, which upon investigation may support the view that it has some value in genito-urinary diseases.

(34.) *Origanum majorana* (Sweet Marjoram). Cultivated as a garden herb in Europe as well as the United States. It is used more as a condiment than as a medicine. It is extensively used, and during recent years the imported article has been adulterated with the leaves of the poison sumach (*Coriaria myrtifolia*). Formerly it was used like saffron and other drugs in domestic practice, especially in the form of a tea.

(35.) *Papaver somniferum* (Opium Poppy). This species and its variety, album, furnish the opium of commerce. The plant is readily grown and very excellent fruits or capsules can be obtained, but considerable work is necessary before we will probably make its cultivation a commercial success. Our work with it this year has been somewhat disappointing, but this is largely due to the fact that we were unable to handle the capsules while they were in the green condition. It is at this time when they contain the largest amount of morphine. In Oriental countries, where the poppy plant is grown, it is usual to select those fruits which are just turning a light brown, making incisions which cause the opium to exude. The incisions are made in the evening, and before sunrise the next morning the juice is collected in jars, the whole being kept until the harvest is finished. In addition to the opium which the opium poppy furnishes, it yields an interesting seed (Maw seeds), which is rich in a fixed oil. The oil is used as a substitute for olive oil, both for culinary and industrial purposes.

(36.) *Pentstemon Lævigatus*, variety *Digitalis*. A perennial herb with opposite ovate-oblong or lanceolate leaves and spikes of light purplish flowers. The plant is indigenous to some of the Central States, and its study may have some scientific interest. At any rate, it has been grown successfully in Ann Arbor.

(37.) *Phytolacca Decandra* (Pokeroot). Both the root and berries of this common but rather striking plant have received official recognition. Preparations are used in the treatment of rheumatism, those of the root being especially esteemed. The berries are collected when ripe; the root should be dug after frost. There are some people who gather the young shoots in the early spring and use them in the same manner as asparagus. It is also of interest that the ashes of this plant contain a large quantity of potassium.

(38.) *Polypodium vulgare* (Licorice Fern). This fern resembles the common polypody and is a native of Washington. It contains a substance which resembles the glycyrrhizin, the sweet principle occurring in licorice root.

(39.) *Pycnanthemum flexulosum* (Mountain Mint). Perennial herb having a pungent mint-like flavor. The plant is nearly smooth, the leaves linear or

lanceolate and somewhat downy. The flowers are slightly purplish and the floral leaves somewhat whitened. The plant has a local use in medicine and contains an interesting volatile oil.

(40.) *Rheum officinale* and *Rheum palmatum* (Rhubarb). This plant resembles the common garden rhubarb, but has a thick, fleshy rhizome, which is the part used in medicine. These plants seem to do well in this climate. While both of these species of Rheum seem to be the plants from which the Chinese obtain their medicinal rhubarb, and while these plants have been extensively cultivated since they were first grown by Soubeiran in 1867, yet none of this cultivated product seems to be equal to that of the Chinese drug. In all probability greater care is needed in cultivating the plant and in pruning the overground shoots. (Figs. 6 and 7.)

(41.) *Salvia officinalis* (Sage). The common garden sage is rather well known and has been extensively cultivated. It flowers in June, and it is at this time that the plant should be cut down and carefully dried. The leaves and tops are largely used as a condiment, but they are also used in medicine, the plant having been very highly esteemed since ancient times. Other species of Salvia are recognized in some of the foreign pharmacopœias. The seeds of some of these other species are used for food.

(42.) *Satureja Hortensis* (Summer Savory). A perennial herb, native of Europe and cultivated for culinary uses. It has a thyme-like odor and flavor. The volatile oil is of some interest and should be investigated.

(43.) *Silybum marianus* (Milk Thistle). There are a great many plants of the compositæ that produce prickly leaves, and the receptacles are more or less spinose. Some of these are used in medicine, as the "milk thistle" and the "blessed thistle," both of which are used somewhat extensively in European countries. The milk thistle has large mottled leaves which are very prickly; it produces large heads of purple flowers. In growing this plant, great care should be exercised that the seeds are not disseminated so as to make it a noxious weed; to prevent this the flowers should be gathered as soon as they appear.

(44.) *Sinapis alba* (Yellow Mustard) and *Sinapis nigra* (Brown Mustard). The mustard plants are extensively cultivated in England, Holland, Germany, and the United States. California furnishes considerable of the yellow mustard and North Dakota of the brown mustard. These plants are easily grown, the seeds being planted in the open in early June, the plants flowering and fruiting in August. The tops are cut down and the seeds obtained by threshing. At the University of Michigan, several varieties were grown, including Chinese yellow, Indian Tori, California brown mustard, and rape seed.

(45.) *Solanum Dulcamara* (Bittersweet). The stems of this plant were formerly official and are included in the National Formulary. It is a very common climbing or twining plant in and about Ann Arbor, and is distinguished by its purplish or blue flowers, which are replaced in the fall by small red ovoid berries.

(46.) *Solanum Douglasii.* A plant somewhat resembling in its general habit the common nightshade (*Solanum nigrum*). It is a native of California, and the interest in the plant lies in the possibility of its being a source of solanine, an important gluco-alkaloid which is used in the treatment of nervous diseases.

(47.) *Solanum nigrum* (Common Nightshade). An annual plant growing in many parts of the United States. There are varying reports as to whether

any parts of this plant are really poisonous. It should be investigated. It has ordinarily been difficult to secure the plant in any quantity, and it is rather gratifying that it can be grown so easily and obtained in any amount desired.

(48.) *Symphytum officinale* (Comfrey). A European plant which is cultivated to some extent, but which has also escaped from the gardens. The root is the part highly esteemed and used in the treatment of pulmonary diseases in domestic practice in Europe. It is rather a coarse herb, having large ovate or ovate-lanceolate leaves, the petioles being attached to the stem and the flowers varying from yellowish to pink or blue.

(49.) *Tanacetum vulgare* (Tansy). This common garden plant was at one time official in the U. S. Pharmacopœia. It has been used in the treatment of a great variety of diseases.

(50.) *Thymus vulgaris* (Common or Garden Thyme). A small evergreen shrub indigenous to Spain and Italy and extensively cultivated in Europe and the United States. Our supply of this drug came to us formerly from Germany. It is now somewhat extensively cultivated in New York State and its cultivation should be extended. It yields thymol, a principle which is largely used in the treatment of hookworm. It is also a valuable disinfectant, being used like carbolic acid. It has the advantage of possessing a more agreeable odor.

(51.) *Verbascum nigrum* and *Verbascum phlomoides*. These two plants resemble the common mullein. They are to some extent used in medicine, but one of the chief objects of cultivating them has been to study the plants at close range with a view of detecting their presence in Digitalis, the foreign drug sometimes being admixed with these leaves.

(52.) *Valeriana officinalis* (Valerian or Garden Heliotrope). A rather pretty herbaceous plant with pinnately compound leaves and large cymes of white or rose-colored flowers. The rhizomes and roots are used in medicine. The plant has been cultivated locally in the United States and should be of very great interest to growers of medicinal plants, as our supplies of the official drug have been very scarce. At the present time we are using a Japanese Valerian and it is very doubtful if it has the same properties as the European plant, which is also the species cultivated in the United States.

For some years past the botanic gardens of the University of Michigan have contained small plots of several medicinal plants. The latter have over-wintered and have, on the whole, done remarkably well. These plants are of considerable interest and should be grown on a large scale. Among these is the ordinary Celandine, which contains a principle which in its physiological action is a good deal like morphine, but is better tolerated than that drug by certain classes of people and especially children. Lavender is an important perfume-yielding plant, and the flowers produced at Ann Arbor are among the most aromatic I have observed. The species of *Chrysanthemum* which furnish insect-powder thrive very well in this locality also.

In addition to the above-mentioned plants, which have been grown

in Ann Arbor, the writer has had under cultivation either in the greenhouse or out in the open a large number of other plants, most of which can be successfully grown. They are:

Aconitum Napellus.
Anemone pulsatilla.
Aristolochia Serpentaria.
Aselepias tuberosum.
Aspidium marginale.
Brauneria angustifolia and *Brauneria pallida.*
Colchicum Burmannii.
Chamælirium luteum (Blazing Star).
Convallaria majalis.
Cactus grandiflorus.
Cypripedium pubescens (Fig. 8) and *Cypripedium parviflorum.*
Daphne Mezereum.
Eucalyptus Globulus.
Gelsemium sempervirens.
Geranium maculatum.
Helleborus niger.
Hydrastis canadensis.
Ilex corniculata.
Iris versicolor.
Gardenia jasminoides.
Jasminum officinale.
Laurus nobilis.
Glycyrrhiza glabra.
Magnolia fuscata.
Melia Azedarach.
Myrtus communis.
Olea europæa (Olive).
Phlox ovata and *Phlox paniculata.*
Passiflora incarnata.
Polygala Senega.
Podophyllum peltatum.
Punica Granatum.
Panax quinquefolia (Ginseng).
Prunus Laurocerasus (Cherry-laurel leaves).
Rosmarinus officinalis.
Sanguinaria canadensis.
Viburnum opulus and *Viburnum prunifolium.*

PRACTICAL CULTIVATION

It is necessary to study the best ways of propagating the plant one wishes to grow. Sometimes this is by means of seeds, as in the case of belladonna and digitalis; at other times it is by propagation of rhizomes, as hydrastis and glycyrrhiza; or, again, it is by root-stocks or prostrate stems, as in the mints. Sometimes both seeds and cuttings may be used, as in the case of hydrastis.

Plants Grown from Seeds.—Most plants can be grown from seed. Mitlacher has given the results obtained with rhubarb, valerian, poppy, matricaria, lavandula, hyoscyamus, gentian, pyrethrum, althæa, aconite, etc. When plants are grown from seeds, especially in a temperate climate, where the growing season is rather short, it is necessary to begin the germination of the seed early in the spring. This must be done then in the house or under conditions where there is some protection. These seeds may be sown either in small boxes or in seed-pans, *i.e.,* shallow, square flower-pots in which the soil is quite sandy or made up largely of broken granitic rock. The soil must be clean and free from organic matter, which is likely to mold.

The seeds should not be planted too deep and should be covered with glass so as to condense or hold moisture. Of course, where there is the necessary attention in keeping the earth moist, this glass can be dispensed with. The time required in germination will vary considerably. Many seeds will germinate well within two weeks; usually probably four or five weeks is necessary. Occasionally some seeds, as the roses, may require a year or two before they germinate. The present tendency is to shorten the period of germination in several ways. The simplest, possibly, is to place the seeds in water for 24 hours. When the seed-coat is somewhat resistant, germination may be hastened by pouring boiling water upon them. Again, some special treatment may be given them, as the use of dilute or even concentrated mineral acids. In the cultivation of mate for many years it was found that the seeds would not germinate unless they had previously passed through the alimentary tract of certain birds. Later it was found that the same end could be obtained by placing the seeds for a short time in solutions of hydrochloric acid. F. A. Miller reports that he has obtained good results in the case of belladonna by placing the seeds for thirty or forty seconds in concentrated sulphuric acid. The germination of seeds may also be hastened by certain mechanical means. This is used when the seed-coat is particularly thick and not easily penetrated by the moisture; when, if they are large, they are filed in one or two places. If they are small they may be shaken with sharp, angular sand until the exterior is somewhat roughened.

After the seedlings have a few leaves upon them they are then set out in suitable boxes, known as "flats." These are about three inches deep and about two feet square, and the soil used should be of a sandy character, containing a certain amount of nutriment, however. The plants must be watched at this point to see that there is no damping off and loss by reason of the attacks of micro-organisms in the soil.

Should there be a damping off and loss of seedlings, then one must study methods for overcoming this. Recently the Department of Agriculture has utilized dilute sulphuric acid for this purpose, which I have shown is the active principle produced whenever sulphur is used in the greenhouse. It is one of the most effective agents for the destruction of insect pests as well as the blights due to fungi and other micro-organisms.

The seedlings are allowed to grow in the "flats" until they have developed a good root system and have three or four leaves. Before placing them directly in the soil out of doors they are acclimated or hardened by placing them in cold frames. This transferal should be done not later than the early part of May. The structure and use of the cold frame is perfectly familiar to the practical gardener. Information regarding the construction of this accessory to the garden can be had of any of the seedsmen. In fact, in many instances they publish small booklets entitled "Vegetables Under Glass," giving information on the tilling of soil during the entire year, and these booklets can usually be had at a very moderate figure. Sometimes the plants are removed from the flats and placed directly in the soil in cold frames. This may give a temporary setback to the plants, as the roots are more or less disturbed by the operation, but if one wishes to continue the experiment in the cold frames, later removing the sash, considerable time will be saved.

If the plants are to be transplanted out of doors, it is very desirable that this should be done as soon as possible after the last days of frost are likely to occur in the given locality. The plants are arranged in rows and set sufficiently far apart so the maximum crop per acre can be obtained. Usually they are so arranged that weeds may be pulled out and the ground worked over.

The above outline may be used for the propagation of most plants by seedlings, but they must be carefully cared for if one wishes to get maximum results. Some plants are rather easily grown if care is taken with their culture, as digitalis and belladonna. Other plants, like hyoscyamus, are cultivated with some difficulty, and very few persons are uniformly successful in growing aconite. Several good practical papers have been published on the cultivation of digitalis, namely, one by Newcomb and another by Borneman. Some facts regarding the growing of hydrastis from seed are given in a bulletin of the Bureau of Plant Industry, U. S. Department of Agriculture, by Alice Henkel and G. Fred Klugh. The subject of growing ginseng from seed is also considered in a bulletin of the Division of Botany, U. S. Department of Agriculture, by George V. Nash. At the present time there is considerable interest in the growing of *Eucalyptus globulus* and other species of eucalyptus, the seeds of which can be obtained from J. M. Thorburn and Company, New York City. A

very valuable monograph on "The Eucalyptus Cultivated in the United States" was prepared by A. J. McClatchie and published as Bulletin No. 35 of the Bureau of Forestry, U. S. Department of Agriculture. In addition to these special plants which have been mentioned there are a large number of plants yielding medicinal products which are grown from seeds and require no more care than the usual garden plants. Among these are calendula, chrysanthemum, roseum, Echinacea, and a number of plants grouped under sweet, pot, and medicinal herbs.

Propagation by Cuttings.—This is a common method of propagating plants. A cutting is a severed portion of a stem, having one or more nodes or buds. They are derived from overground shoots, as in the carnation, rose, geranium, and coleus, or where the plant produces rootstocks or rhizomes, they are made from these rather than from the overground shoots. In propagating plants from rhizomes the latter are cut into pieces, each of which has one or two buds, and these pieces are planted. The propagation by means of cuttings or rootstocks is extensively carried on in the cultivation of peppermint. A. M. Todd, who has been growing peppermint on a very extensive scale, has given in some detail the method of propagating this plant in an article published in the *Proceedings of the A. Ph. A.* for 1903, p. 277. A later article on the cultivation of peppermint in the United States is one prepared by Miss Henkel and published as Bulletin No. 90, Bureau of Plant Industry, U. S. Department of Agriculture. Hydrastis is another drug the plant of which is commanding considerable interest and is being propagated by means of rhizomes. There are three good articles which treat of the practical cultivation of hydrastis; namely, one by John Uri Lloyd, in the *Proceedings of the A. Ph. A.,* 1905, p. 307; another by Alice Henkel and G. Fred Klugh, in Circular No. 6, Bureau of Plant Industry, U. S. Department of Agriculture; and a third by J. C. Baldwin in the *American Journal of Pharmacy,* April, 1913.

In the case of both ginseng and hydrastis, one-year-old plants are frequently supplied by growers, and, while taking everything into consideration, this is not desirable, yet there may be conditions where, for experimental purposes, they may be used. It should be emphasized that it is not merely a matter of getting rhizomes or young plants, but a very careful study should be made of the soil and light

conditions which favor the maximum returns from the crop. The use of manure for increasing the yield of both crop as well as constituents should proceed with a good deal of caution until we know more about the subject.

HARVESTING THE CROPS

As drugs represent the different parts of the plant, they are harvested in different ways and sometimes more than one crop may be obtained in the course of the growing season. There are certain general rules, however, which might be followed for each class of drugs, classifying them according to the parts of the plant which are used:

(1.) *Seeds.*—Sometimes the principal object is the seed, as in mustard, which, by the way, can be sown in the open, thus yielding a crop in 8 or 10 weeks. When most of the fruits are mature the plants are cut down by means of a scythe, collected, and carried to the drying shed or barn, where they are spread out and allowed to dry. The seed is threshed out and the chaff separated by winnowing. Seeds are collected when fully ripe.

(2.) *Fruits.*—Fruits are usually collected for pharmaceutical purposes when full-grown, but unripe, *i.e.,* while green and of maximum size. At this stage the active principles are at the maximum. The fruits are collected by hand, those being selected are at the right stage of maturity, leaving the plant undisturbed. At times it may not pay to make this selection, and the main stalk, with the fruiting branches, can be cut down with a scythe and the fruit stripped off at the convenience of the worker. This is rather important to remember; it may save undue exposure to the hot sun and enable the farmer to collect the drug during the cooler part of the day, preparing it afterward under more favorable conditions. This procedure was followed with conium. In the case of this plant the leaves are also used in medicine, so it is possible to cut down the entire plant, separating the leaves as well as the fruits and thus securing double crop. It is possible to secure about 500 pounds of leaves and 100 pounds of fruits per acre.

With the opium poppy it is customary to scratch the surface of the green capsule, causing a light yellowish-brown, milky juice to exude. This juice, when scraped off, constitutes the opium of commerce. It was not possible in the experiments this past summer to

carry on this operation, and so the capsules were cut off and allowed to dry. They should yield from 0.2 to 0.3 per cent. of morphine. In addition, however, to the morphine content of the dried capsules, considerable interest attaches to the seeds contained in them. These seeds, commonly known as maw seeds, are very rich in a fixed oil. This is without narcotic properties, of a straw-yellow color, a pleasant almond taste, and an appearance resembling olive oil. The seed contains from 50 per cent. to 60 per cent. of this oil, which may be obtained by expression. It is also used in the manufacture of paints and soap. Each capsule will contain 3 grams of seed. The yield per acre is approximately 30 pounds of capsules and 50 pounds of seeds.

Chenopodium or American Wormseed.—This plant produces long spikes of very small fruit. It is not known at just what stage they contain the maximum amount of volatile oil. The plant is several feet in height and develops a very brittle stem. The whole plant is cut down by means of a hatchet and brought to the drying-shed, where it is spread out to dry, the fruits being separated from the plant. It is quite likely that the leaves and stems also contain considerable volatile oil. It would no doubt be desirable to distil the oil from the green plant, thus saving a great deal of labor in the handling of the crop. The still could be run continuously and require very little attention, so that part of the time could be used in the preparation of the herb for the distillation. About 10,000 plants could be obtained per acre under proper conditions of culture, and this would mean a yield of about 100 pounds of volatile oil.

(3.) *Flowers.*—Flowers should be gathered either in the bud condition or when they are about to open and are at their best. At this stage they contain the largest quantity of desirable principles. In some cases, as with German chamomile, what is commonly known as the flower, but really flower-cluster, is collected in its entirety. The simplest way that I have found is to run the hand upward from below flowering clusters, thus collecting the stalks which come through the fingers. In this way one can gather five or six or more flowers at a time. The flowers are dried by spreading them out on paper. Chamomile continues to flower from about the middle of July to the first of September. The yield of chamomile flowers

would be somewhere between 500 to 1000 pounds per acre. At the present time this drug is commanding a price of about 50 cents per pound, so that the returns are very excellent. Marigold furnishes an important medicine, the strap-shaped yellow florets being separated from the head of flowers. This involves more labor than in the handling of chamomile, but nevertheless does not require skilled labor. The method of separation can be very easily learned, and performed even by children. Marigold flowers from the latter part of June until on up to frost. One can collect a large number of flowers throughout the season, and the yield will be from 100 to 200 pounds of drug material.

(4.) *Leaves and Herbs.*—The leaves and flowering and fruiting tops of a great many herbaceous plants are used in medicine. The harvesting of these is rather simple, but considerable space is required for drying them. The shoots can be cut off by means of a scythe and spread out, either on the floor or in suitable trays, or hung up on wire to dry. This method of collecting would apply to belladonna, henbane, Indian hemp, sage, grindellia, catnip, sweet marjoram, thyme, tansy, etc. Nearly all of these plants would yield anywhere from 500 to 1000 pounds per acre.

One should exercise a good deal of care in harvesting and drying these plants, yet my experience shows that one does not need to go to the extremes as stated by some who have written on this subject. For instance, it is ordinarily stated that the individual leaves of digitalis should be carefully separated, the stalks and midrib carefully removed, and the leaf spread out on trays and carefully and quickly dried, using artificial heat. The drug which I collected ran unusually high in active principles and was dried with the minimum attention and care because of the difficulties in securing labor. The cluster of root-leaves, with a portion of the underground root and stem, was cut down with a hatchet or spade. In one case the whole clusters of leaves were strung on wires and allowed to dry. In another case the leaves were torn apart and scattered over the floor. The drying in every instance was very slow, and I rather anticipated disappointing results. The assays made by Doctor Edmonds, of the University, showed the yields to run about three times as high as the official standard. *Belladonna* is of especial interest because every part of the plant, with the exception of the basal portion of

the main stem, is recognized by the pharmacopœia. Of course, one cannot get the largest yield of roots if one is cutting down the plants right along with the expectation of getting a banner crop of leaves and tops. From plants which are set out in early June, one can get from two to four crops of the leaves and shoots per season, as this plant will continue flowering until very cold weather comes. The roots of the plants which have been pruned in this way are not so large. If one wishes to get large leaves the plant should be allowed to grow during the entire season. The tops then can be cut down, or the entire plant with roots and stem can be removed from the soil, the stem portion being separated by means of a hatchet. Roots, however, which are two or three years old are preferred, so that the stems of the plants which one wishes to allow to over-winter can be cut down some time in September, depending on the weather. That is, if the plants continue to grow and frosts do not come, the entire overground portion can be cut down and will give from two to four hundred pounds of herb. We secured per acre nearly 1000 pounds of leaves and tops and 200 pounds of roots.

(5.) *Roots.*—When roots are used in medicine the plants are allowed to grow for at least two or three years. At this time they contain the largest proportion of bark tissues in which the medicinal constituents reside. These constituents vary during different periods of the year, and particularly the growing period of the plant. As a rule the poisonous principles preponderate when the vegetative processes are about to stop, as in the fall of the year. A similar condition seem to prevail in the spring, just before the plant begins to produce new shoots. When plants are under cultivation it is a comparatively easy matter to locate last year's plants and to spade them out just as soon as frost is out of the ground. Of course, there is a possibility of loss from freezing if plants are allowed to over-winter, but I am inclined to think that the medicinal activity is improved by over-wintering, as accompanying the medicinal constituents there are usually a number of bitter and even acrid substances which are destroyed by the cold of winter. Among the root-yielding drug plants which we have grown at the University of Michigan are belladonna, marshmallow, poke, burdock. The yield of each of these from first-year plants would be from 500 pounds to 1000 pounds.

CURING AND FERMENTATION

Recent investigation of drug constituents seems to show that the quality can be improved by subjecting them to a sweating or curing process. During this operation certain aromas are developed which enhance their value. This is probably best seen in the curing of tobacco, where we begin with a leaf that has neither flavor nor aroma, but develop a final product that is fit for the enjoyment of gods. The value of tobacco depends not so much upon the nicotine content as upon the generation of minute quantities of those constituents which give it its particular flavor and aroma. Of course, in the curing of tobacco there are other qualities which must be developed, as that of proper combustion.

Apart from climate and soil there are three prime factors which underlie the curing of tobacco, namely, heat, moisture, and light. Of course, there must be proper ventilation, and the time element is an important one. It was with the view of studying these fundamental changes that a considerable number of Havana and Pennsylvania tobacco plants were grown at the University gardens. The results thus far would seem to indicate that tobacco may be made a valuable product in this vicinity, an acre yielding at least 40,000 large leaves.

In quite a number of medicinal plants the poisonous constituent is generated by what is known as a mother substance. The latter is broken down in the process of curing, thus generating a number of important principles. This is well illustrated in the curing of vanilla, where the odorous principle known as vanillin is produced during the fermentation. A number of years ago Mr. Knox, a student in the College of Pharmacy, University of Michigan, showed that in cola the caffeine was produced in a similar way from a mother substance. It is quite likely that in belladonna, digitalis, and a number of other plants a slow drying will enhance the value of the leaves. In other words, if the leaves are first allowed to wilt, preferably in the shade, and to some extent allowed to sweat, care being taken that the temperature does not get too high, it is likely that superior drugs will be produced. This is one of the most interesting results of our work at the garden during the past summer.

One of the most interesting plants that we had under cultivation during the past summer was rhubarb. The plant yielding this drug

resembles the garden rhubarb, but produces large, fleshy rhizomes which it seems quite likely will over-winter. I had similar plants growing in large packing-boxes placed on a roof when I was conducting experiments in Philadelphia. These lived from year to year. The roots may not be as large or of as fine a quality as those produced in China, but the obtaining of a finer drug material is doubtless merely a matter of a better understanding of the cultivation of the plant. The use of fertilizers and a certain amount of protection may be required.

BIENNIAL PLANTS

There are quite a number of medicinal plants that do not yield drugs until the second year, such as some forms of henbane, caraway, etc. Such plants will need some sort of covering or protection so that the loss from freezing would be reduced to the minimum. Again, it may be that some of these plants will be found to be valuable in the first year. The studies made in the United States have proven this to be true of digitalis, and, in fact, the digitalis leaves of the first year's plants grown at the University of Michigan were three times as strong as that of the official article. This was not true, however, of henbane, but this is in part due to the fact that the leaves of the henbane were badly attacked by the potato beetle, which consumed the fleshy portion between the veins, in which the greater part of the active principle resides.

There is another possibility in the case of plants like caraway, which do not ordinarily set fruit or seed until the second year. It is possible, by starting the plants early enough in the greenhouse and planting them outdoors very early in the spring, to crowd two seasons into one. We did not succeed in doing this with caraway this year, but quite a number of biennial plants bore fruits in the first summer here. This offers very great possibilities in the matter of preserving the fruits of this type of plant and cultivating it to better advantage.

PLANT SELECTION AND BREEDING

It is well known to nearly every one how our agricultural crops have been improved by selecting and breeding. Owing to the minor importance of medicinal plants as compared to farm products, not much has been done in scientific selection. More attention has been given, up until now, on the possibilities of the use of chemical fer-

tilizers. *A priori* we can expect the same results in the study of medicinal plants as we have seen with other plants which have been studied scientifically. The experiments made with cinchona in Java will be paralleled with other plants. Here trees running low in alkaloid have been, by selection and hybridization, made to yield as high as 15 per cent. of alkaloid. Furthermore, it has been possible to study them with the view of increasing the most desirable of these alkaloids, quinine. It will be found that one can accomplish almost anything reasonable if he will but start the experiment and continue until he achieves his result. At this point it also should be stated that climate and soil may have some influence, but from our experiments this summer we must conclude that these factors are not so important as the natural conditions in Michigan were not very promising.

In the case of stramonium and also belladonna there have been some scientific experiments made which show that of these plants we have several varieties. Of belladonna there is not only the one form bearing purple flowers, but there is another which yields yellow flowers. The relative alkaloidal value of these two plants has never been established. The same is true of stramonium, of which we have not only the common form, producing spinose capsules, but another form in which the capsule is perfectly smooth. Of the comparative alkaloidal content of these two varieties little is known.

PERFUME-YIELDING PLANTS

The two points of difficulty in the way of producing perfumery materials in this country are lack of information and experience and the cost of labor. The first of these by itself is no great obstacle. The art of distillation is already practiced, not only in the cases mentioned above, but in the considerable industries of extracting the oils of peppermint and of eucalyptus. To grow lavender and distil its oil does not require a specially greater intelligence than to grow and distil peppermint. The processes of maceration and enfleurage can be learned independently, especially by persons of some chemical knowledge or acquainted with kindred arts; but any one undertaking perfumery-making on a large scale should certainly have expert assistance. To know what plants to grow and where and how to grow them requires experiment, which might well be conducted by the State Experiment Stations or by persons of means

who are willing to risk a little capital for the public good. But persons of moderate means, who derive their support from other sources, may in suitable localities wisely conduct experiments on a small scale with the purpose of expanding their operations in case of success. Nothing good is to be expected from that class of experimenters who, without capital, knowledge, or patience, are merely seeking bonanzas.

The relation of the perfumery business to the labor question depends somewhat upon the manner in which it is undertaken. Three types of method may be distinguished:

(1.) A company or a capitalist may procure land, set up a plant, and hire labor to grow and harvest the crop, as well as to extract the perfume. This enterprise might confine itself to the production of raw material, or might add the preparation of perfumes for the market.

(2.) An extracting plant might be established with the purpose of securing its material from adjacent growers, whose product at first might be contracted for in advance. Such an enterprise would follow the same general method as a creamery and might be conducted coöperatively. A modification of this type would be the plan somewhat followed in the peppermint business, under which the producer of the herb hires his product distilled at an establishment making distilling its business.

(3.) Farmers, gardeners, etc., can grow perfumery plants together with their other crops and extract their own perfumes. In this case the perfumery crop would be a side line, at least at the start.

The first of these plans would have the advantages of system and operation on a large scale and presumably of suitable appliances and expert direction. It would, however, have to encounter the problems presented by the labor question in their fullest strength, while the impatience of capital for quick returns would stand in the way of the gradual surmountal of difficulties. An undertaking of this type, pure and simple, would be the least encouraging of all. If, however, the capitalist were himself an expert and capable of managing the business, the outlook would be much improved.

The second plan would have the great advantage over the first that small growers would probably accept a less price for their crop than it could be grown for with hired labor on the capitalist's farm.

The small grower could often afford to do this, because by utilizing his own labor and that of his family more fully, he could make an addition to his income without increasing his expenses; and, in other cases, because the returns from his farm by this means, if not large, would at least be larger than he could gain from other crops. This plan, conducted coöperatively or otherwise, is a good one, but could be entered upon more safely where some individual has already proved by experiment the possibility of commercial success.

The third plan has much to recommend it, though not as final and exclusive. The success of individuals on their own farms would almost surely be followed by enterprises of the second and, perhaps, of the first type. Yet the assumption is to be deprecated in advance of experience that perfumery-making cannot in some situations be profitably conducted as a domestic industry. A small still is not expensive, nor is the apparatus for enfleurage. A considerable item of attar of roses, for instance, might, aside from the rough work of growing the bushes, be produced by the women and children of a family.

The case should be mentioned in which wild material or waste material of other industries can be had for the gathering. A few wild plants are already, and more may be, used for this purpose, while the fallen orange flowers may be had gratis or for a small sum by picking up—a labor to be expedited by spreading cloths. That class of labor which digs ginseng and gathers berries and nuts for the market would be forthcoming upon a demand of this kind.

FUTURE DEVELOPMENTS

There is a good deal more to the farming of drug plants than mere harvesting and disposing of the crop. If the farmer understands the science of pharmacy and is intimately acquainted with the products that his drug crops yield, and their economic uses, he will enjoy many advantages and obtain not only competence but an independence that will make the work far more attractive than mere farming. Probably in no position which one can select are there the opportunities and possibilities for the man of ambition and initiative. Very few plants are used at the present time in the crude form. They are mostly made up into tinctures or fluid extracts, and in many instances the active principles are separated, as the essential oils.

Any one who takes up drug farming will sooner or later desire to engage in some form of manufacturing. This is not only desirable from the point of view of the cultivator of medicinal plants, but also of benefit to the consumer. If, for instance, one is growing plants yielding volatile oils, it will be quite natural for him to install stills for obtaining the oil, and if it is of a high grade it follows quite naturally that he would like to put it up in special containers with his name on the label. High-grade finished products always command a good price, and there is a great deal of satisfaction to the man who can produce them in having his products so recognized.

(1.) *Essential Oil Industry.*—At the present time there are several essential oils which are distilled from our native plants. Among these are sassafras, wintergreen, sweet birch, cedar, wild ginger, and sweet golden-rod. All of these oils are largely used and attention to any one of them would furnish a very lucrative field. The Government issued twenty years ago a bulletin on "Can Perfumery Farming Succeed in the United States?" This was printed in the yearbook of the Department of Agriculture for 1898. In addition to the plants above mentioned, we have been growing thyme and orris-root.

(2.) *Alkaloids and Proximate Principles.*—It would be a great boon to our chemical industries if many of the chemicals now made abroad were manufactured here. During the past few years some of the active principles have been extracted from American drugs. One American firm is now producing large quantities of atropine. Comparatively large quantities of the active principles of belladonna, digitalis, hydrastis, etc., are used in medicine. The camphor industry in the Southern United States is but an example of what can be accomplished in our country. There was hardly an incentive to develop this industry, as almost every precedent pointed to the fact that it would be almost impossible to manufacture camphor at a price to compete with that produced on the island of Formosa. Yet the statistics are showing that even this can be produced here at a profit.

(3.) *Specialties.*—Some plants are used in some special form, and it would be well for the grower to be conversant with the uses that the crude drug is put to. Insect-powder, for instance, is prepared by powdering the dried, unopened flowers or flower-buds of two distinct species of chrysanthemum. One can readily see what a very

great advantage it would be to not only grow the plants yielding insect-powder, but to grind them and put up the powder for the use of the trade. This would save transportation in the bulk of the crude drug, and the labor involved in powdering would be well repaid. At the present time much of our insect-powder comes from Japan and retails for about 80 cents a pound. The yield of this powder per acre should be about a thousand pounds. Of course this would involve a great deal of labor in picking the flowers at the right stage of development, and they would have to be very quickly and carefully dried so that the active principle would be retained.

The illustrations in this paper have been kindly furnished by Professor E. L. Newcomb, of the University of Minnesota. His medicinal plant garden is probably the finest in the United States and his experiments have been unusually successful, covering a period of nearly ten years.

ON THE USE OF MOTION PICTURES IN MEDICINE*

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In Charge of the U. S. Army Medical Museum, 1916-1918

THE motion picture is based on the fact that the human retina retains the impression of an image about one-eighth of a second, and the eye will, as a rule, fuse pictures so offered as a continuing one; but the eye will not fuse the interruption of a lighted picture on the screen into a continuous impression when the interruptions are fewer than sixteen to the second. For this reason the universal standard for the taking and projection of these pictures has become 16 to the second, and the celluloid film is so prepared that there will be sixteen separate pictures to each foot of film taken or projected. One of the great color-picture schemes went into the discard simply because the result could not be obtained with less than 32 pictures to the second, or just double the amount of film ordinarily used; it might have stood this extra cost, but the standard machines were all set for 16 pictures to the second.

Now a motion which requires for its completion one second of time is taken by the camera at the rate of 16 to the second; when it comes to the projection room, it is projected at this rate and the picture appears on the screen in the same time relation as it did under natural conditions when taken. Should we take this same picture at the rate of four pictures to the second, when this picture comes to the projection room it is thrown on the screen at the rate of 16 separate views to the second just as before, but the result is that the position-time ratio is completely changed and the objects appear on the screen to be moving at a rate four times as rapidly as before. It is just as if you had taken every fourth picture in the original 16 to the second picture, with the result that the figures appear to move on the screen four times as far in the same time.

Now when you take the pictures at 64 to the second, and they come to the projection room, there being four times as many pictures to go on the screen in 16 to the second, it takes four times as long

* The first of a series of papers explaining the making of motion pictures and extolling their value in the study and teaching of medical and surgical subjects.

for the figures to reach the same points as before, and the motion is slowed down four times from the normal rate.

Trick pictures are produced by double exposures, double or triple printing, cutting of the negative, screening, fade-outs, fade-ins, dissolves, etc., in infinite variety. One's imagination seems to be the only limit.

From the above the reader should clearly understand that:

(1.) Sixteen pictures per second both in the taking and the projection is the normal.

(2.) Less than 16 pictures to the second in the taking and 16 to the second in the projection are the rapid motion pictures.

(3.) More than 16 pictures to the second in the taking and 16 to the second in the projection constitutes the slow motion pictures.

(4.) The making of diagrams and photographing them in such manner that the projection on the screen produces the illusion that they are in motion.

Jenkins, of Washington, D. C., the inventor of the first projecting apparatus, has recently perfected a camera with which over two thousand separate pictures may be taken in a second, and this method permits the studying at leisure of rapidly moving objects when coupled with a foreground and background of squares of a known dimension—say four-inch squares—and with a black-faced clock with white hands recording the thousandths of a second on each picture. The reason for a stationary black-faced clock [1] with a white revolving hand is that white is photographed at a much higher speed than black.

One should always remember that when the object, especially when near, is moving more than a small fraction of an inch in a second that it becomes blurred when taken under normal conditions. Hence its great value of recording the pictures rapidly, and projecting them normally.

Let us take several concrete examples. There are 5280 feet in a mile, and an object moving at the rate of one mile an hour passes a fixed point at the rate of 88 feet per minute or 1.4⅔ feet per second, or at the normal rate of taking pictures at 1.1 inches per second for

[1] The ordinary phonographic disk, properly prepared, regulated to revolve at sixty revolutions per minute instead of the normal seventy, may be used in place of the clock.

each picture. At the rate of four miles an hour, the object would traverse 4.4 feet per second, or 5.8⅔ inches per picture. But the finger motion in an operative procedure or in a spasmodic seizure is much more rapid than this.

The great majority of men can and do visualize motion in two dimensions when a diagram is offered to their attention; very few can or do visualize the motion in the third direction.

The eye in looking at objects always moves more or less, and the image on which it is focussed makes a more definite impression in one part of the retina than in another. It follows, therefore, that one is able to see more definitely objects in rapid motion at a distance than when up closely. When the retina is very close to the point of the radii of the sphere of vision, crossing the centre of the sphere of vision, which is slightly different for each eye, a very small movement causes a large change of position in the outer end of the radius, this together with the association in position gives us our sensation of relation to distance from us, and among the objects looked at of length, width and depth, and with these three dimensions of space there comes a fourth relation called time: for all objects move in relation to all other things.

These three dimensions represent to us the three diameters of the sphere which are at right angles to each other; the one revolved cuts the sphere into halves, the other, into quarters, and the third, into eighths. Just as if you had taken eight cubes, fastened them together into a cube, and put them into a lathe, and turned them down to a sphere. Now just as the objects vary in relation to these three planes of our personal sphere, so do they vary in their pictures on the retinæ of our eyes.

Now when we take the pictures we have the moving figure pictured against the inside of a cube with the floor and both sides divided into four-inch squares and with the elapsing time recorded on the face of the black circle by the revolving hands of the clock in the 1/1000 of a second.

Then take these pictures, throw them singly on the screen, and chart each cycle of movement for each part of the body that it is desired to study in the two directions shown. The result will show at once any difference in the rhythm of the movement whether of the individual member involved or its relation to other parts of the

body. They will at once disclose on one chart all relations of movement of any part of the body to all other parts of the body in the two dimensions of space included in the pictorial record. Should it become a matter of importance to know the relationship in all three dimensions of space nothing is easier than to take a simultaneous motion picture at 90° apart and chart all three relations in space and time on the same chart. A special ruling for depth could easily be placed between the regular rulings.

With the four-inch squares over the entire field it becomes an easy matter to measure very closely any distance passed over and with the time marked to 1/1000 of a second, even closer approximations may be made.

How very useful would be a room the walls of which were set with white four-inch square tiles held with black cement seams for the study of irregularities of gait, for limps, for spasmodic actions of all kinds! The trained eye sees far better what transpires after seeing an action in living motion, then slowed down on the screen, and then each individual picture examined!

The student would first study the patient, then the normal picture, then the slow down, then the individual picture. He would draw his conclusions, write them down and again go over the pictorial record to see if his conclusions are correct with the record, and continue to do so until they are. Cases that to the unaided eye appear to be precisely the same will sometimes under this analysis be found to be quite different, and then when found by the simultaneous position-chart they will stand out quite plainly; so much so that one wonders why it was not seen before the chart was made.

One of the most interesting pictures for teaching purposes that I have seen was made by Dr. R. Tunstall Taylor, of Baltimore, Maryland, a case of flat feet. In this picture he first had the patient photographed walking about the field in his naked feet so that the action and condition of the limbs were evident. To enable him to get a field as free as possible from blood so that it might be photographed, he put on a rubber bandage, operated, and had the motion picture taken. When this was complete, he had a trained animationist go over with him the entire picture, and reproduced it in animated diagram, step by step, in the same order as that of the operative procedure. The showing of this animation was preceded by an animation

of the anatomy of the parts and an explanation of the action of the various muscles upon the bony parts, so that the entire process was visualized. By reversing the process, and placing on the screen the animation and following this with the pictures of the operative procedure the latter will be much more easily followed and understood.

Many men have a personal skill in the small details of operative procedure upon which their operative success in great measure depends which might easily be bettered if they would take the pains to have a time and distance slow-down picture taken of their hands while engaged in the actual work. If this should be done it would not only enable them to observe the exact movements upon which the skill depended, but would also permit them to teach others so that this skill would not be a lost art with any accident that might occur to the individual operator.

I have seen a most interesting animated series of diagrams that told the story of the reflex and the pathways of the semi-circular canals in the production of vertigo, and one of the most interesting motion pictures that I have ever seen was one of an aviator undergoing his tests for elevation. It was most illuminating to see his intelligence and responsiveness slow down as his oxygen supply lessened, and then to see how certain he was that he had full possession of all of his faculties.

How beautifully the animated diagram gives itself to the study of the action of the individual muscle, of the group action, of the opposing action; how easy to show with this most flexible of tools that every muscle must have its opponent, otherwise, one contraction would end its activities. How nicely the impulses begun in nerve terminals could be shown with the various relays on the road to the centres! How plainly the reflexes could be shown! The individual parts of the movement might be demonstrated, and then one by one added to the combination until the entire complex could be shown with its incomings and outgoings with the muscular and other responses.

How valuable a picture could be made if some one man who truly knew all of the present thought and belief of what transpires in the nervous system would make a diagram of what he felt took place when the retina received a sight impression; of the pathways to the various centres and association centres; the reflex back for the muscular reaction desired; of that exceedingly nice adjustment of balance

in tension between the muscles which move and position the body as it sits on the piano stool; between those which control the position of the scapula and clavicle; of the humerus in its relation to the two bones; of the balance between the contraction of the muscles around the elbow joint. Study that wonderful balance of contracting muscles which position the fingers as the artist plays upon the instrument. Think of that exquisite coördination between the eyes, which see a combination of black lines and spots of the music notes and the muscles by which these images are at once converted into musical sounds by an exact contraction between the muscles, often involving the positioning of all ten fingers many times per second!

What an interesting picture might be constructed by showing the tract passing in motion from outside of the spinal cord, and forming a column within the cord; to see tracts form starting from points within the spinal cord, the pyramid tracts descending from cortex cerebri, passing through the substance of the parietal lobe to the internal capsule, continue through the posterior limb on to and through the ventral part of the pedunculi and the pons to the medulla, divide into two tracts, the lateral pyramid tract which crosses to the opposite side of the spinal cord and descends as the lateral column of the corduntil, the neurons terminate in the cells of the anterior horn, the smaller bundle, the anterior pyramidal tract pass down at the upper limit of the cord without crossing through the anterior columns, and ending in the cells of the anterior horn crossing in the anterior commissure before so doing, the delayed or pre-terminal crossing.

See the descending tracts form from the lower brain centres; see Monakow's bundle spring from the red nucleus of the tegmentum cruris cerebri; see the thalamo-spinal tract arise in the thalamus, pass into the tegmentum; join the fibres of the rubro-spinal tract; cross with them to the other side; and go down in the lateral column to the cells of the ventral column. See the tecto-spinalis tract arise from the roof of the mid-brain; decussate with its fellow beneath the aqueduct of Sylvius; and descend in the ventral column.

See the vestibular spinal tract start from the nucleus of Deiters; pass downward in the ventral column uncrossed.

See the upgoing fibres come in from the spinal ganglia; see

these divide into three different groups; see one go to form the posterior columns; see another fibre arborize with a cell of the posterior horn and a fibre emanate from this cell go upward as the spino-cerebellar tract; see another arborize with a cell of the posterior horn; see the fibre from this cross over to the opposite side and all go upward as the spino-thalamic tract.

Rather interesting to see the root fibres start from the cells of the ventral horn, pass by the anterior roots to the peripheral nervous system, to have the associations of the brain and the cord put into motion in two dimensions before one's eyes; to have the various characters of diagnosis made by the interruption of the various paths of ingoing and outcoming impulses; to show the mechanisms of the various characters of symptoms resulting from these interruptions of impulses, etc., etc., using the actual photograph when possible and giving the explanation in animated diagram. The author, writing out in animated diagram just what his personal interpretation of the symptoms was, in exactly the same way that he would describe the matter with words so that other men might know his thought, never forgetting that he was using a new method of expression—that of pictures in motion—and that the artist can only express that which is given him; for when he fails to do this he is apt to make wrong suggestion for the author, just as dangerous as any misprint in type would be in a text-book.

The mitotic cell division is not easily acquired as a mental picture by the student: the first time that he studies the diagrams and the text. I will defy any student to read over fertilization in any text-book of embryology and get a clear concept of this process the first time that he reads it over. How greatly it would facilitate the study of medicine would some man who felt that he truly knew, not that he truly knew, just what the process was from the time when the male cell reached and impregnated the female cell within the body.

How easy it is to have the ovum, by the aid of animation diagrams, begun with the germinal spot; surround this with the germinal vesicle; and both with the nuclear membrane, then flow in the vitellus, the vitelline membrane, the zona pellucida, the albumen, and the corona radiata.

But how easy to tell this story of the fertilization of the ovum with the spermatozoon! Have the head of the spermatozoon pierce

the envelopes of the ovum, become imbedded in the cell substance and form the male pronucleus, and as it does this have the body and tail disappear. The protoplasm of the ovum now shows lines of convergence toward the male pronucleus and as it sinks deeper into the cell it is approached by the female nucleus, and they become connected by an achromatic spindle and the intranuclear network of each undergoes changes (chromatin) by which chromasomes are formed. These consist of loops derived from each pronucleus, and gradually reach the equator of the achromatic spindle, where they become intermingled and one-half of each goes to each pole of the achromatic spindle, where they are reconverted into loops, the loops into net-work, and the net-work into a daughter-nucleus. At the same time the cell substance divides into two, and the sub-division of the ovum has begun.

Have this impregnated and dividing ovum come down the fallopian tubes, losing the corona radiata and the zona pellucida in so doing, and then becoming fastened to the uterus, the solid cell-mass eating its way through the uterine mucous membrane and becoming fixed beneath the epithelium. Then see the morula become the blastodermic vesicle by vacuolation with one layer of cells on the outside of the ectoderm. At one pole of the ectoderm there is a mass of cells, the entoderm, embryonic cell-mass; see this embryonic cell-mass grow around inside of the ectoderm, giving rise to the cavity from which arises the intestines, yolk sac, etc. (archenteron); see it also form another cavity within itself, the amnio-medullary cavity; see the floor of this cavity become the embryonic area, the primitive streak.

See the formation of the mesoblast, both somatic and splanchnic; see the formation of the chorion of the notochord; note the formation of the embryo within the amnion; see the formation of the chord, the neurenteric canal, the alimentary canal; see the gradual formation of the brain, of the nerves and ganglia, the formation of the mouth, of the genitalia, of the lungs, heart, liver, etc., etc. Behold the child delivered at birth! Let the student read over the text once or twice; receive a lecture or so on the subject, after he shall have looked at the story as told on the screen and he will then be ready to get a final look at the pictures; for his mind will then be better prepared to receive the information offered to him and he will understand the text, for he will have seen the motions which the words undertook

to describe to his memory. He will have had the story told him by his eyes, the most cultivated sense which he possesses to connect him with the outside world, and the one whose records are cut deeper into the tablets of the brain than any other one of the senses. This will take less than half the present time, with the study included, and it will in addition require less labor on the part of the professor; for when he shall have once prepared the lecture and the moving picture, any subordinate can deliver it to the class, and the professor will have time to do original work and to prepare himself to act as an answerer of questions by the students.

What could be better to teach anatomy than the development of the mouth and the anal opening and the tube between, coupling in the lungs, the liver, pancreas, the twist of the colon as it grows, the placing of the transverse colon, the formation of the great omentum, of the lesser cavity of the peritoneum. A very interesting picture could be made of the formation of the many convolutions of the small intestine; how the peritoneum was folded around it; how the blood and nerve supplies entered; and how the lymphatics escaped. There is no limit to the subjects, and the first man who writes out anatomy in moving pictures and animated diagrams will give medicine the greatest jump forward that it has ever received; for it will enable the student to understand and read his anatomy in three dimensions in the place of one, the skin, muscles, arteries, veins, nerves and bones can be shown in movement in two dimensions and the third can then be read into the picture by the student himself.

If I have drawn my illustrations largely from anatomy, it is because I have taught anatomy for years and know of the difficulties the student has in acquiring and retaining his anatomical data, the use of which is to be of such importance to him in the future practice of his profession. As striking examples can be given for obstetrics, pathology, physical diagnosis, or any of the other specialties of medicine.

Many reject the thought of using the motion picture with which to teach the student, because to thus relieve him of the drudgery of work is to take from him his mental training, feeling that that which has been easily attained is easily forgotten. The same reasoning would reject the use of the lecture in explanation of the text-book. It says in effect because we studied by candle and lamp-light, because

our forefathers travelled by stage-coach, that we should refuse the use of the electric light to our present-day student; that we should when living in Philadelphia refuse to travel to New York by railroad train or airplane when we wished to visit the city of New York. As the electric light is an aid to facilitate the studies of the oncoming generation, as the modern train enables the student to get to the point more quickly and in better shape than did the stage-coach, so does the moving picture and the animated diagram enable the student to learn more easily and rapidly; it explains to him in two dimensions, and in time relation his mind has only depth to add to the picture, a feat already accomplished by motion pictures, but not yet put to practical use. In still photography, the ordinary diagram, he has the time and two dimensions to supply. Hence the advantage of motion pictures in medicine.

Medicine

RICKETS: WITH SPECIAL REFERENCE TO ITS ETIOLOGY AND EARLY RECOGNITION

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The etiology of rickets has long been a disputed question. Researches into its causation have been numerous. Various theories have been advanced, and, as is usual in such cases, none of them is free from some defect. That rickets is the result of defective hygienic conditions is maintained by some observers. But if this were the actual cause of the disease then it should be absolutely non-existent amongst the better classes, which is by no means the case. Want of exercise is another alleged cause, but by investigation we find that infants who have abundant exercise every day nevertheless develop rickets. We are, as a matter of fact, thrown back on the old view that rickets is a nutritional disease, and this is borne out by facts. Recently it has been set down to lack of the necessary vitamine. But, after all, what is a vitamine? We prefer to maintain that rickets is the result of lack of a certain principle. Let us call it the anti-rachitic principle for the sake of simplicity.

During the course of several years of observation in out-patient practice we have collected facts regarding rickets, and we have here selected a thousand consecutive cases for analysis. As is always the case with out-patients, it is very difficult to follow them up, and even to obtain anything like a complete statement of facts, but we think our figures are as nearly accurate as it is humanly possible to make them. First, as to facts relating to feeding and home conditions.

	Mode of Feeding	
Group A	Artificial food	476
" B	Condensed milk	254
" C	Dried milk *	240
" D	Breast fed (mother's health bad)	14
" E	Breast fed (bad home conditions)	13
" F	Breast fed (6 or more pregnancies)	3

Home Conditions of Groups A, B, C, D, and E as far as could be ascertained

Group	Excellent	Satisfactory	Very indifferent or bad
A	182	249	35
B	23	183	48
C	71	163	8
D	0	0	13
E	0	1	2

* This only came into use comparatively recently, otherwise the figure would probably have been greater.

This leaves twelve unaccounted for, as it was quite impossible in these cases to obtain any reliable information as to home conditions which existed. Even if we include these under the last column we find that out of 1000 cases only 118 gave evidence of unhealthy surroundings, or only 11.8 per cent. of the whole number. Now if we look at the mode of feeding we find that no fewer than 970 were artificially fed. *Curiously enough, not one of these cases was fed on fresh cow's milk.* Thus 97 per cent. of cases were artificially fed with some substitute for fresh cow's milk. The remaining thirty cases, or only 3 per cent. of the total number, were breast fed, but in every one of these cases the milk was probably defective. From these tables alone one can almost certainly conclude that where good breast milk or fresh cow's milk is not used in infant feeding rickets is almost sure to result, and that rickets is due to lack of that something in the food which we have called the anti-rachitic principle. Doubtless unhealthy home surroundings favor the incidence of the disease; but, on the other hand, some very bad types of rickets have been encountered in infants living in well-appointed homes with every luxury in the way of a large, airy nursery and a good garden. These infants had, however, been brought up on some patent food or on dried milk, which is certainly lacking in the necessary anti-rachitic principle. In England, rickets is a very common disease, and this is no doubt owing to the fact that so many infant foods are used and even sanctioned by the medical profession. Recently, too, dried milk has been largely used in infant feeding. The introduction of this form of food has been insidiously brought about, largely owing to the misguided efforts of medical officers of health, many of whom have no knowledge whatever of infant feeding. It has even been stated that dried-milk feeding prevents and cures

rickets! Needless to say, these statements have not been made by infant specialists. As a matter of fact, dried milk is now a common source of the disease, and may also cause infantile scorbutus in those fed upon it.

We are firmly convinced that if artificial foods, condensed milk, and dried milk ceased to be used rickets would become a comparatively rare disease. It is certainly a very curious fact that out of one thousand consecutive cases of rickets not one of these had been fed on fresh cow's milk. Indeed, although rickets does occur in infants so fed, in our experience it is a comparatively rare occurrence, the reason being that fresh bovine milk contains the anti-rachitic principle already referred to, and which is certainly lacking in every manufactured food, as it is also in dried and condensed milk of every variety. Unfortunately, the tendency both amongst the laity and the profession is to use as a substitute for breast milk one of the numerous manufactured articles which are euphemistically termed "infants' foods." In reality they are more of the nature of poisons, and always lead to trouble when continued for any length of time. The great advantage of condensed and dried milk is their perfect sterility, but this can be attained to a large degree with pure bovine milk by simply scalding it. We have never known an infant fed on scalded milk to develop tuberculosis. This is surely proof enough that such treatment of milk renders it tubercle-free. The advantages alleged, therefore, regarding condensed and dried milks are not so important, after all, when the same can be obtained with fresh cow's milk with very little trouble. And be it remembered, scalded cow's milk will not cause rickets or scorbutus. Both condensed and dried milks may and often do.

If we wish, therefore, to stamp out rickets we must stop the sale of patent foods altogether. They are quite unnecessary. Even for older infants oat flour is infinitely superior as a foodstuff to any of the artificial foods. As regards condensed milk it should only be used as a temporary expedient in certain cases of difficult digestion under strict medical supervision. Dried milk should only be employed in cases where fresh cow's milk cannot be obtained, as when on a journey, and its sale should be controlled accordingly. The way in which substitutes for breast feeding are advertised to the public is most reprehensible, and it is the duty of the Ministry of Health

to take up this matter; but so far they have done nothing beyond establishing a costly system of child welfare centres at many of which manufactured foods and dried milks are recommended! Until these centres are under the direction of infant specialists in receipt of a competent salary they will serve only as advertising and distributing centres for the infant-food manufacturers.

Now let us look for a little at the severity of the cases observed at various age periods. We have classified them as slight, moderate, and severe. The last group includes cases with nervous manifestations or marked bone changes.

Age	Slight	Moderate	Severe	Total
3 to 6 months	98	12	0	110
6 to 9 months	29	352	25	406
9 to 12 months	86	290	44	420
1 year and over	12	20	32	64
Totals	225	674	101	1000

It will be seen, therefore, that the majority of the cases showed a moderate degree of severity, while 22.5 per cent. were slight and 10.1 per cent. severe. Of the severe cases several showed very bad bone changes, of which the half-tone may be taken as a type (Fig. 1). It is that of a girl of 4½ years, an obviously neglected case, who was not seen until a fortnight before the photograph was taken. She is probably a mixture of congenital syphilis and rickets. Of the slight cases, doubtless many of these would not have been recognized as such save by the skilled pædiatrist. The appalling ignorance which exists as to what really constitutes rickets is remarkable. Thus many infants, improperly fed on substitutes for cow's milk, suffer from slight rickets and yet gain weight and look quite plump. Consequently they are regarded as healthy and may even gain prizes at those most pernicious festivals known as "baby shows." Many such illustrations adorn the advertisements of infant-food manufacturers. We have in our possession a photograph of this kind, that of a baby who was brought up on an advertised food, and who made quite an excellent picture in spite of the fact that he suffered from rickets, as evidenced by bronchial catarrh, profuse sweating and convulsions. In fact, it is a knowledge of the slighter evidences of rickets which is of importance, as no one can miss recognizing the disease in its graver manifestations.

FIG. 1.

Well-marked rickets in a female child of 4½ years.

The reasons for bringing an infant for treatment in the first instance are very varied, as the subjoined table will show:

(1.) Late in teething	311
(2.) Bronchial trouble	269
(3.) Not walking	162
(4.) Sweating in the head	96
(5.) Indigestion, constipation, etc.	49
(6.) Convulsions	47
(7.) Other nervous manifestations	32
(8.) Bow-legs and other bone changes	32
(9.) Nervousness	2

In many instances more than one complaint was recorded, but the chief one has been classified as far as possible in each case.

If early cases of rickets are to be recognized and prophylactic measures taken before the disease has made any great headway, we must understand clearly what constitutes this disease. There is still far too much mistaken teaching on this subject. Thus in one text-book, under the heading of symptomatology, the first statement made is to the effect that "the skull is large in size, the forehead broad and very prominent in profile," while the same writer distinctly says that "rickets is most frequently observed in children from 2 to 3 years of age." As if the disease began so late as the second year, and as if the earliest symptoms were bone changes! All this, of course, is most erroneous teaching, and has done much in the past to prevent the disease from being checked before more or less permanent bone changes have been allowed to develop. Now, these bone changes are really only the *results* of the disease known as rickets. They do not constitute the actual primary disease any more than we can allege that the mental changes which develop as the result of cerebro-spinal meningitis are symptomatic of that disease, or that chronic endocarditis is symptomatic of acute rheumatism. The mental changes and the heart lesions are results only; so too with the bone changes in rickets. Bearing this important fact in mind, we have further to recognize that rickets commences very early in life, usually about the sixth month. In rare cases it may even start before this. The majority of cases, however, probably develop definitely when the infant should be cutting his first tooth; that is to say, between the sixth and eighth months. Much, no doubt, depends on when the infant began to be improperly fed. Artificial foods are not com-

menced until some months after birth, as is often the case; then the evidences of the disease may be later in making their appearance than in cases where they are commenced soon after birth.

Now what constitute the early manifestations of rickets? These we are in the habit of dividing into three distinct groups, *viz.:* (1) Catarrhal phenomena; (2) nervous phenomena; (3) vasomotor phenomena.

The *catarrhal phenomena* are often the earliest evidences. They include gastro-intestinal and bronchial catarrh. In fact, at the outset we are inclined to regard rickets as being essentially a catarrhal disease. Vomiting, diarrhœa, nasal, aural, a bronchial catarrh, and even eczema, or a catarrhal condition of the skin, may be encountered in such cases. Doubtless it is difficult in the first instance to pronounce a catarrh occurring in an infant as due to early rickets, but if the infant is not fed on breast milk or pure cow's milk then we are warranted in suspecting rickets and attending most carefully to the feeding. If we do so we will be on the safe side. If, however, we neglect to bear in mind the possibility of rickets in such cases, then some, at least, of such infants will later on show unmistakable evidences of the disease.

The *nervous phenomena* which we are inclined to picture to ourselves are convulsions, tetany, and laryngismus stridulus; but these may not appear until the disease has made some progress. Much earlier, as a rule, and therefore of greater value in checking the disease, are restlessness and irritability, disturbed sleep, tossing about in the crib, and "jumping" or "twitching" when startled. Facial irritability may sometimes be met with, but this often develops somewhat later. Some of these symptoms may be due to other causes, but when present should always put the physician on his guard.

The *vasomotor phenomena* include profuse sweating, which is very typical of rickets. The infant sweats very profusely while asleep, so that the pillow becomes quite wet, and beads of perspiration may even be seen on the forehead. When the finger-nail is lightly drawn across the skin a red line remains, and this is undoubtedly a sign of vasomotor disturbance. Such phenomena are often, along with the catarrhal symptoms, the earliest manifestations of rickets, and should always be enquired for.

Another important matter to be constantly kept in mind is that rachitic infants do not grow so rapidly as healthy ones. They may put on weight from increase in flabby and inert tissue, but they are not gaining in strength. This gives the lie to the alleged importance of baby balances. Weighing infants is quite useful if done intelligently under the supervision of some one who is able to estimate correctly the value or otherwise of the figures obtained.

Thus we have tried to show what is meant by the disease known as rickets, and how important it is to recognize it before its results have been made felt in the shape of bone changes. This is especially important in the case of female infants, as pelvic changes may mean untold trouble in later life, and unfortunately in some cases may even be the cause of death during child-bearing. When we face the fact that rickets is not in the first instance a disease of bone, but a disease of alimentation, we shall have made a great advance. When, too, we come to recognize that rickets could be practically stamped out if the sale of "infant foods," dried milk and condensed milk were strictly regulated, we shall make for progress in dealing with this widespread disease. Every medical man should be warned against the use of anything save breast or fresh cow's milk in infant-feeding, except as a purely temporary or emergency measure. We would have written large in the mind of every parent and practitioner these words: *If breast milk is not available, then the only proper substitute is scalded cow's milk, pure, or diluted with water.* Acting on this dictum, rickets, we believe, would become a rare disease; for there can be no doubt whatever that it is neglect of this golden rule that leads to trouble, no matter what the environment may be in which the infant is being reared.

We cannot close without calling attention to some fallacious methods of treatment in vogue at the present time. Cod-liver oil is a well-recognized remedy. Recently petroleum oil has in some quarters taken its place. The latter is worthless as a remedy in cases of rickets, as it is a mineral oil; nor is cream "quite as good" as some would have us to believe. Phosphorus, too, is a useless drug. It is generally given along with cod-liver oil, and of course any benefit which follows must be attributed to the oil and not to the phosphorus. Lime water is worse than useless, as in any case it only contains an infinitesimal amount of lime, and consequently can

have no remedial effect whatsoever. The laity believe greatly in it, doubtless because they have been told that rickets is due to deficiency of lime salts. Recently we have been told that dried-milk feeding is a cure for rickets. Regarding this we can only say that we have seen too many cases of the disease in infants so fed to believe that it can cure a disease which it undoubtedly may produce! Such are some of the fallacious methods being adopted in dealing with a disease for which the very best treatment is prophylaxis by attending to the various warnings we have given, and by discountenancing most strenuously improper methods of infant feeding on every possible occasion.

SORENESS OF THE TONGUE AS AN INAUGURAL SYMPTOM OF PERNICIOUS ANÆMIA *

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A FEW years ago, William Hunter propounded in a manner most emphatic the view that pernicious anæmia is due to oral sepsis. Many of us were not, however, convinced that he had proved his thesis, even though he based it upon a study of 75 cases of true Addisonian anæmia. The cause of pernicious anæmia is still locked up in the casket that shelters leukæmia, cancer and sarcoma; but I am optimistic enough to believe that some will soon find the key. But even if oral sepsis is not the cause of pernicious anæmia, there are, at times, oral symptoms that bear, in their intensity and chronology, such a striking relation to the affection as to constitute more than a mere accidental phenomenon. The cases I have to report seem to me to illustrate this point.

CASE I.—Mrs. M. D., married, fifty-four years old, a native of Australia, was seen with Dr. Beverly S. Ober, of Springfield, Massachusetts. On Christmas Day, 1912, she fell and broke her arm. A severe brachial neuritis followed. About six months later she began to have a biting, stinging sensation in the tongue. The normal coating disappeared, leaving a raw and tender surface. The burning sensation gradually spread to the inner side of the cheeks and lips. As time went on, however, it affected chiefly the tongue, which also became streaked with red lines. The papillæ became implicated, and the burning increased. The tongue felt, as the patient put it, as if it had been scraped and had no top. Food had a queer taste. The character of the food itself made little difference in the abnormal sensation. When I saw the patient, the tongue was of a carmine color and very tender to the touch. A small ulcer was present on the left side of the cheek. The teeth were in good condition. Aside from a little pyorrhœa, the patient had never had any dental trouble. A single tooth, found defective on X-ray examination, had been extracted.

* Read before the Section of Medicine, College of Physicians, Philadelphia, March 27, 1922.

On physical examination, nothing more of moment was found. The blood, except for some anisocytosis, was practically normal.

Having no other satisfactory explanation to offer for the glossitis, I told Doctor Ober that Mrs. D. would probably develop pernicious anæmia; and this prediction was verified. When I chanced to see Doctor Ober, in November last, he told me that the patient had eventually developed pernicious anæmia, and had died of it.

Case II.—Two weeks ago, I had the privilege of seeing with Dr. J. M. Godfrey, of Philadelphia, Mrs. A. M., a native of Philadelphia, who presented the clinical and anatomical picture of pernicious anæmia. Five years ago, she began to have trouble with her tongue. A sense of diffuse soreness and a feeling as if the tongue had been scorched by hot tea, were experienced. She is sure that there was no connection between the soreness of the tongue and bad teeth. Long before the tongue became sore, she had gotten plates; and her son-in-law, an excellent dentist, had kept the few remaining teeth, as well as the plates, in good condition. The surface of the tongue was never cracked or ulcerated. Two years ago, or three years after the soreness of the tongue began, Mrs. A. M. found herself growing weak. This weakness has gotten progressively more intense, and is now very marked, constituting the patient's chief complaint. The tongue is no longer sore. For the last three months, she has had nausea and vomiting before breakfast. Her appetite, however, is good. So far, she has not lost much of her original weight, which, two years ago, when in her opinion her illness began, was 240 pounds.

Mrs. M.'s tongue was, when I saw it, small, atrophic, pale, smooth, velvety and free from any coating whatever. The papillæ had entirely disappeared.

Case III.—Three days after I saw the second case, I was asked by Dr. William K. Müller, of Germantown, to see Mrs. McG., a woman of sixty-eight years, whose chief complaint was pain in the knees. Noticing her extreme pallor, I asked whether she had ever had a sore tongue, and elicited a surprised affirmative. It appears that Mrs. McG.'s illnss began two years ago, with great pain in the tongue, which felt as if it was ulcerated. After a few months, during which she lost strength rapidly, the tongue condition improved; but it became worse again last summer. At the time of my visit, the tongue was no longer sore. In appearance, it was the counterpart of that

of Mrs. M. (Case II). It was very small, pale, smooth, velvety and somewhat glazed. The papillæ were totally atrophied. There were only two teeth—incisors—left. All the others had been removed about twenty years before, plates having been worn since that time. There was a little pyorrhœa about the roots of these two teeth; but they were not painful, or in any way troublesome. The blood count, made the next day, bore out the diagnosis of pernicious anæmia. It showed 680,000 red cells, 6900 white cells, and 15 to 20 per cent. hemoglobin. There was marked poikilocytosis, megalocytosis and microcytosis. No nucleated red cells were present. The differential count was as follows:

Polymorphonuclears	64 per cent.
Small mononuclears	28 per cent.
Large mononuclears	8 per cent.

Doctor Müller had a blood transfusion done. Ten days later, the red cells were 1,380,000—about double what they had been before, and the hemoglobin nearly 50 per cent.

The bond uniting these three cases is, primarily, a severe glossitis, which either directly inaugurated or by some time preceded the pernicious anæmia.

While there is no actual proof of a poison in pernicious anæmia, the blood destruction and the well-known spinal cord changes strongly suggest the existence of a slowly acting toxin. It may temporarily exhaust itself or be neutralized, which explains the remissions, but it is never, or hardly ever, entirely destroyed. The same poison probably acts upon the tongue and mouth. It is at times present long before the blood alterations are sufficient to attract attention, although a careful examination might reveal some tell-tale change.

In many respects pernicious anæmia bears an analogy to septic endocarditis—both are of long duration; both are subject to remissions; both bear some obscure relation to the spleen; both tend to a fatal termination. By making a blood culture on special media, such as Noguchi's, it may perhaps be possible to find the virus responsible for pernicious anæmia.

The principal point that I wish to make in this brief report is that in all cases of sore tongue in which syphilis and distinctly local causes can be excluded, the possibility of pernicious anæmia should be borne in mind.

SOME NERVOUS SYNDROMES PRODUCED BY LESIONS OF THE SPINE

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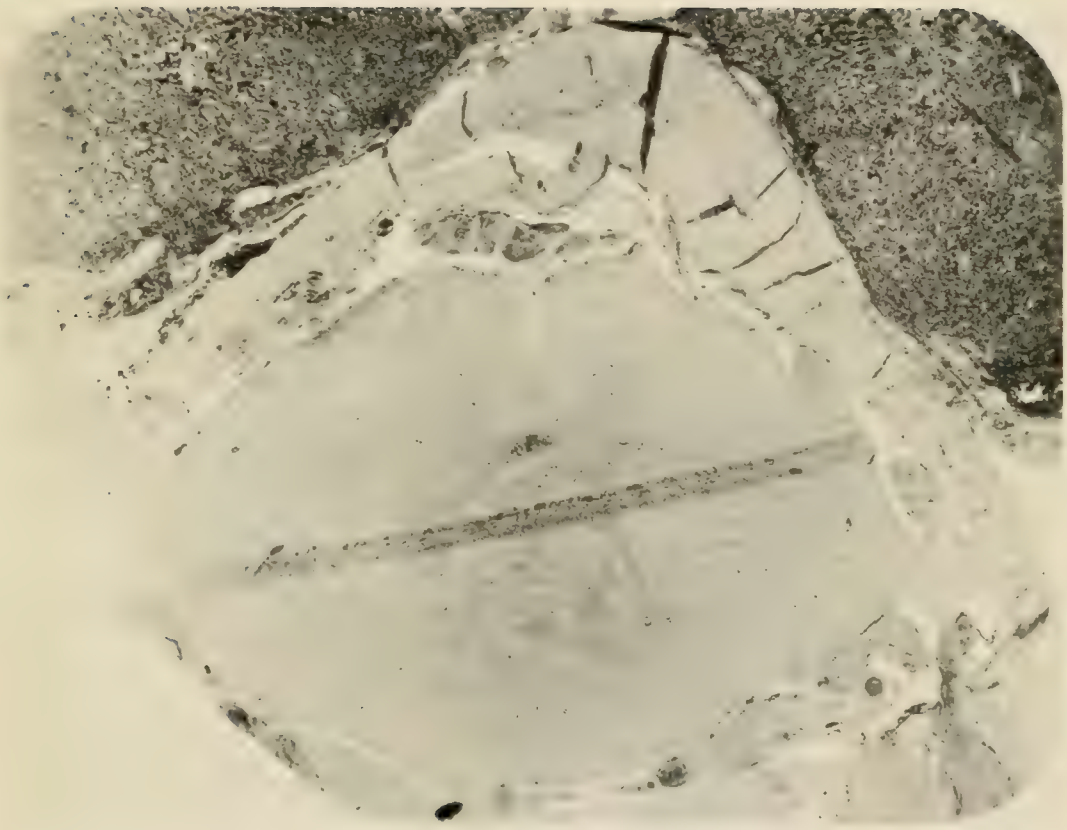
By means of presentation of case histories, specimens and skiagrams I shall attempt to point out how many clinical syndromes, at first sight apparently due to brain or cord disease, may be caused by hidden bone lesions. The lesson taught by such cases is of particular value to the neurologist whose mind is on the nervous structures while he is prone to omit, at times, a sufficient survey of the bony casing of these structures. Orthopedic surgeons, on the other hand, are apt to commit the opposite error.

1. *Transverse lesions of the cord,* with more or less complete loss of motion and sensation below the level affected, when coming on rapidly with a febrile disturbance, are easily taken for acute myelitis of some kind or even meningitis, when in reality an inflammatory or neoplastic process of one or more vertebræ is present. Neurologists in particular need to bear in mind that there is such an affection as acute pyogenic osteomyelitis of the spine, that the paraplegia of Pott's disease may come on suddenly in the absence of deformity, and that primary sarcoma of the vertebral arches or bodies may manifest itself by fever and rapidly developing cord symptoms. Carcinoma of the spine is always secondary and usually involves the vertebral bodies, whereas sarcoma usually is primary and often involves the arches. I will not discuss the well-known subject of vertebral carcinoma except to warn you that in case the primary growth is unrecognized, the case for a long time may pass for one of neurasthenic tender back, or of sciatica, intercostal neuralgia, or "neuritis." It is also well to be aware that in carcinoma as well as in tuberculosis of the vertebral body we may have complete paraplegia from mere œdema of the cord produced by dural adhesions, without any deformity of the cord. This is well seen in Fig. 1. The specimen was obtained from a woman who developed a transverse cord lesion a few weeks after removal of a cancer of the breast.

Fig. 1.



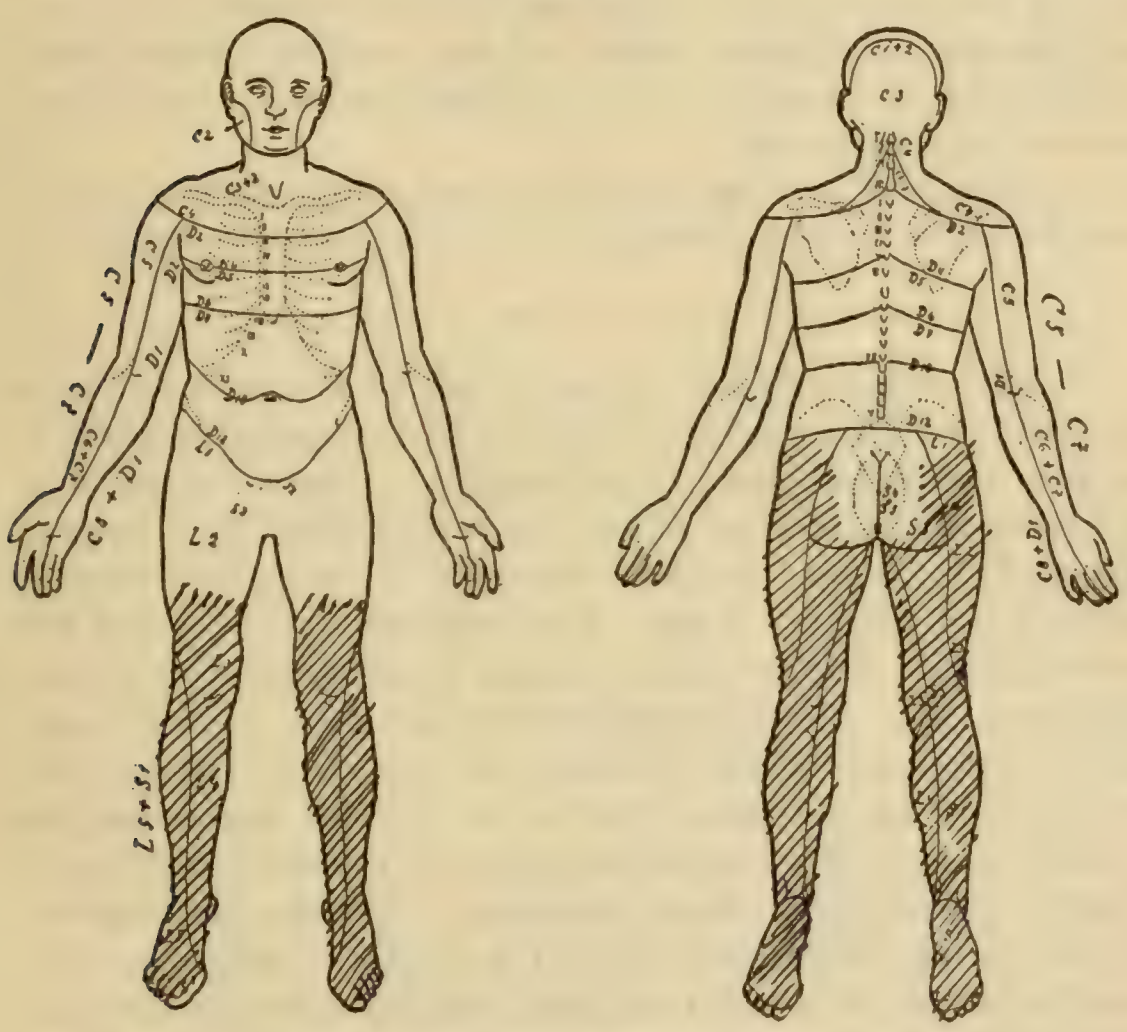
Metastatic carcinoma body of fourth thoracic vertebra causing paraplegia, though not deformed.

Fig. 2.

Case I. Osteomyelites of fifth lumbar vertebra.

There was no recurrence in the breast and at necropsy no secondary tumors were found anywhere except in the bodies of the third and fourth thoracic vertebræ. You will note that the shape of the cord is normal and that there is no invasion of either cord or meninges by the tumor growth which has almost entirely replaced the bone of the vertebral body.

Fig. 3.



Case IV. Anæsthetic area before the operation.

Benign spinal tumors, such as osteoma and fibroma, are less frequent as causes of compression of the cord. I will not discuss fractures and dislocations except to mention that callous formation may cause compression of the cord and paralysis weeks or months after a fracture which had been unattended by any immediate cord symptoms.

2. *Pain Syndromes.*—Occipital, cervical, brachial, intercostal,

lumbar and pelvic neuralgias as well as sciatica, coccygodynia, so-called meralgia paræsthetica, etc., may be caused by a variety of spinal lesions without the character or distribution of the pain differing from neuralgias arising from causes not connected with spinal lesions. There may or may not be associated motor and trophic symptoms. In some instances, these pain syndromes are merely premonitory, and followed by symptoms of cord compression. This is true of such common affections as Pott's disease and primary and secondary malignant disease of the vertebræ. Other spinal lesions prone to cause these pain syndromes are malformations and osteo-arthritic processes.

In presenting our cases we shall arrange them according to their bone lesions rather than according to the nervous syndrome presented.

PYOGENIC OSTEOMYELITIS OF THE SPINE

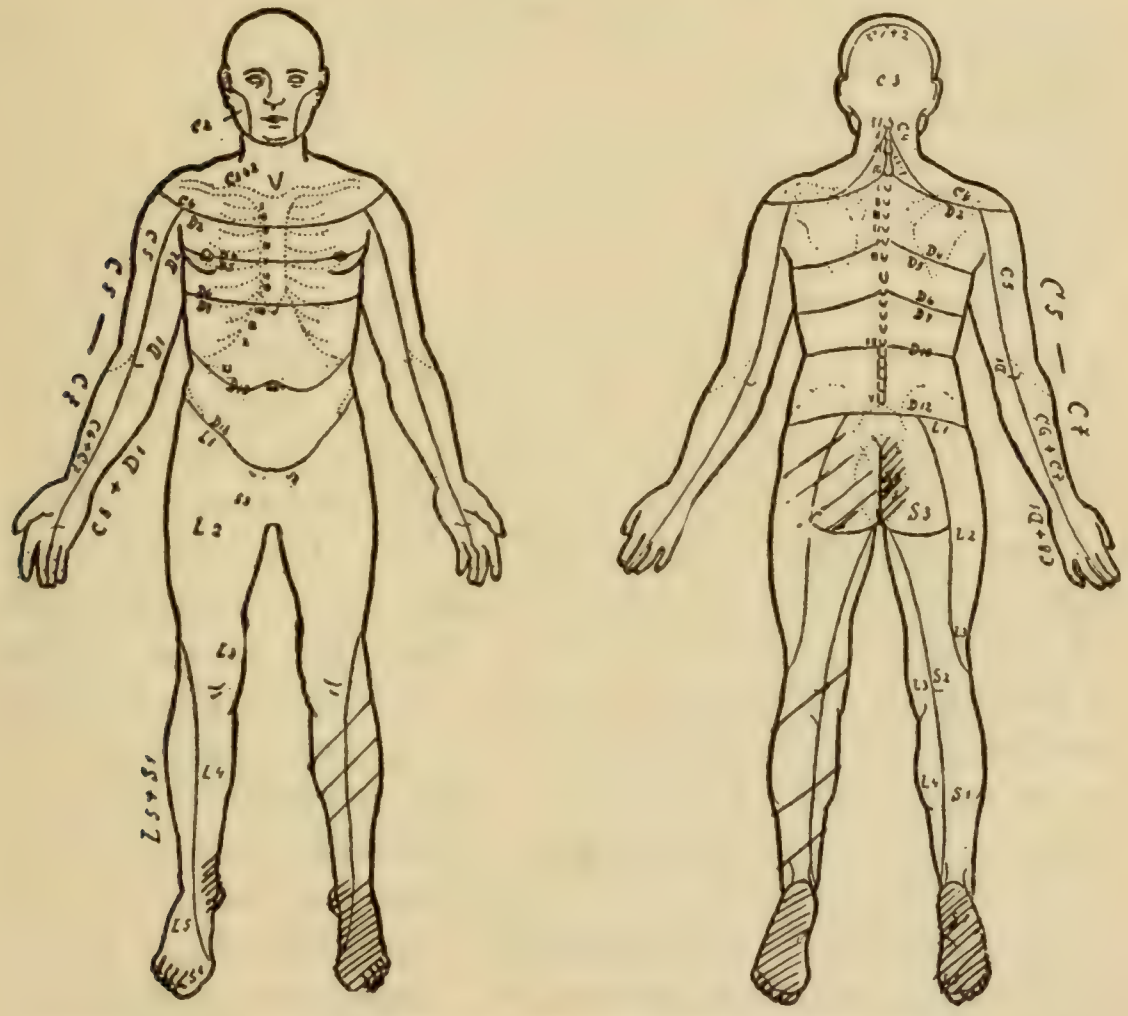
This is a decidedly rare affection, but, as the two cases to be presented will show, serious mistakes will occasionally be made if its existence is not known or is forgotten. A complete review of the literature, based upon 87 cases, was contributed by a German writer, J. Volkmann,[1] in 1915. One-half of the patients were between 8 and 17 years of age. Local cutaneous abscesses had frequently preceded the bone infection, and a trauma had been present in several cases. Staphylococci (aureus and albus) were the commonest organisms. The arches were more frequently affected than the bodies of the vertebræ. Rupture of the bone abscess into the vertebral canal with subsequent meningitis, or externally with formation of a paravertebral abscess, is common. Secondary development of foci in other bones existed in 14 per cent. of the cases. The onset is sudden, often with high fever, with indefinite pains at first; later localized pain and tenderness of some regions of the spine. Early and marked leukocytosis is the rule. Correct clinical diagnosis had been made in only one-third of the cases. The diseases most frequently mistaken for acute vertebral osteomyelitis were: Tuberculous spondylitis, typhoid fever, meningitis, pneumonia and rheumatism. The mortality was 42 per cent., but in the group of cases early recognized and operated on, only 16 per cent.

[1] *Deutsch. Zeitschr. f. Chir.*, Vol. 132, p. 445.

Case I.—*Osteomyelitis of fifth lumbar vertebra following punctured wound of foot with symptoms simulating both appendicitis and meningitis.*

This girl, now 13 years old, spent the summer of 1920 at a summer camp in Wisconsin. One day she stepped on a thorn which caused a punctured wound of the right heel. A local abscess formed

Fig. 4.



Case IV. Anæsthetic area two months after operation.

within a few days and eight days after the injury there was high fever and the complaint of severe pain in the right iliac fossa and region of the right hip. Appendicitis was suspected and a laparotomy was immediately performed, but nothing abnormal was found. The pain and high fever persisted and the child was delirious much of the time. Meningitis then was suspected and a spinal puncture was attempted, but no fluid obtained. Before the laparotomy, rönt-

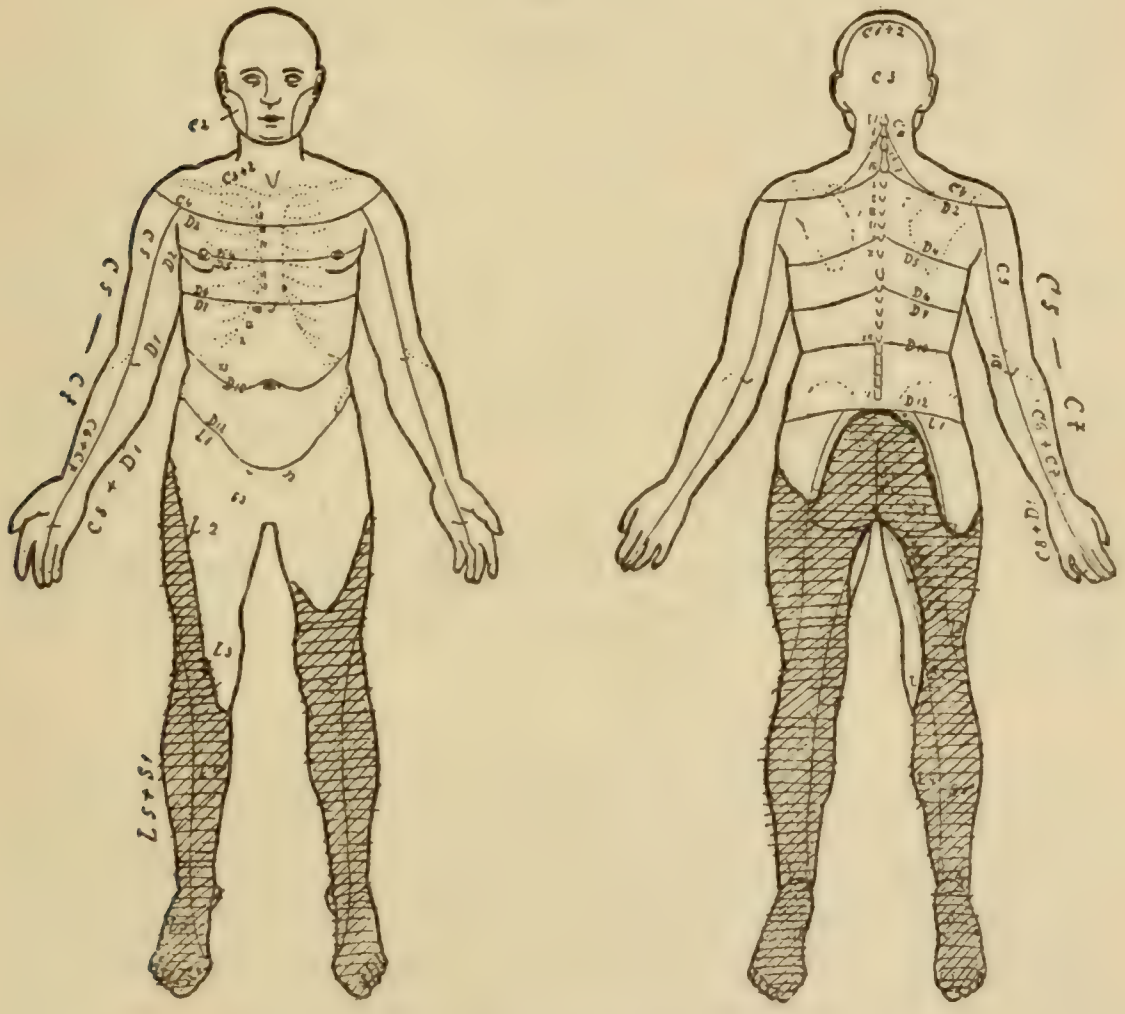
genologic examination of the spine and hip had been made, but no evidence of osteomyelitis was found. A staphylococcus was obtained in a blood culture made a day after the laparotomy.

When first seen by me four weeks after the injury, the patient was extremely hypersensitive in the region of the right hip and right side of the back and abdomen. The tenderness and pain on motion were more extreme than we usually see them, even in cases of meningitis, and there was no pain or tenderness about the head, neck or upper part of the trunk. The temperature was 102.4° and the leukocyte count, 18,400. I felt that we almost certainly were dealing with acute osteomyelitis, but whether of the spine, pelvis or upper end of the femur could not be determined without röntgenologic examination. Fortunately this settled the matter very promptly, as it showed a distinct irregularity on the right side of the body of the fifth lumbar vertebra, the right transverse process of which could not be made out (Fig. 2). The patient was transferred to the service of Dr. D. B. Phemister. He operated at once and on exposing the fifth lumbar vertebra in the median line pus appeared and the bone was found to be largely necrotic. There was a rapid improvement as far as pain was concerned, but the irregular fever and leukocytosis persisted for weeks. When she left the hospital on October 22, the leukocyte count was 20,300, but the discharge from the wound was very slight and there was no evidence of other foci of suppuration. Within a few weeks she began to complain of pain and stiffness in the upper part of the left arm and on December 13, she was brought back to the hospital and a swelling of the arm had also appeared. Doctor Phemister exposed the upper part of the humerus, which was the seat of a suppurative osteomyelitis. Two small sequestra were removed. There was still a little discharge from the lumbar wound. The general condition of the patient was good. In February, 1921, she had to return on account of a new osteomyelitic focus in the left ulna and it was also necessary to open a psoas abscess. In April it was necessary to curette the vertebræ and there were new foci in both tibiæ and the left fibula. In November an operation was performed on the right tibia and new pus pockets about the vertebræ have repeatedly required opening. In

January, 1922, a new focus in the proximal phalanx of the right fourth finger had to be opened. In February an operation was performed on the left tibia and a new psoas abscess was opened. In spite of all this the patient's general condition has been good.

Case II.—*Sudden paraplegia following ten days of fever and chills. Operation eight months later followed by recovery from paralysis.*

Fig. 5.



Case IV. Area of anæsthesia at time of first examination.

A woman of 20 years seen with Dr. E. W. Ryerson, was taken ill suddenly on May 30, 1920, with fever, chills and pain in the shoulders and legs. After ten days of fever, she suddenly became completely paralyzed from the waist down. The pain in the legs then ceased abruptly while that in the shoulders remained. Retention of urine was present for four days and was followed by two

weeks of incontinence. The spinal fluid at that time was normal except for a cell count of 12. At the time, acute poliomyelitis, and later, caries of the spine were suspected. When I first saw the patient in January, 1921, there was spastic paralysis of both legs with bilateral Babinski sign, knee and ankle clonus. There was some weakness of the abdominal and lower thoracic muscles. Cutaneuos sensibility was normal, but vibration sense and sense of passive movement were impaired in the lower extremities. Lumbar puncture yielded a clear fluid under low pressure with positive globulin test and a weak Lange reaction (0112221000). A röntgenogram of the spine showed a peculiar punched out defect in the fourth thoracic vertebra, the significance of which was not clear, but together with the history of the onset led to a tentative diagnosis of osteomyelitis of the spine. This was corroborated when Doctor Ryerson performed a laminectomy and discovered at the level of the fourth thoracic vertebra an epidural mass of the appearance of granulation tissue containing in its interior a few drops of pus. The patient gradually recovered the use of her muscles and is now able to walk about unaided.

Note.—This patient was presented to the Chicago Neurological Society by Doctor Ryerson on October 20, 1921. Proceedings reported in *Archives of Neurology and Psychiatry,* February, 1922, Vol. 7, p. 270.

TUBERCULOSIS OF THE VERTEBRÆ

I shall not discuss the classical Pott's disease with its gibbosities and angulations, but confine myself to relating two cases which illustrate the occasionally rapid onset without direct bone symptoms and the perplexing problems which arise in connection with the planning of a treatment, which at the same time, will relieve the cord compression and give the bone disease an opportunity to heal. A dilemma often presents itself in consultations between orthopedist and neurologist in such cases, the former with his mind on the diseased bone, insisting on immobilization and the avoidance of any surgical measures, beyond, at most, an Albee operation; the latter clamoring for immediate mechanical relief of the cord compression.

Case III.—*Rapid painless paraplegia from tuberculous caries without deformity. Recovery following decompressive laminectomy.*

A woman, 21 years old, was six months pregnant when seen in January, 1913. After five weeks of numbness and cramping of muscles, first in the toes of the right foot, then in the whole limb, she developed a rapid paraplegia with increased reflexes in the legs and diminished sensation below the level of the costal margin. There was no pain nor was there any deformity or rigidity of the spine. However, the röntgenogram showed distinct evidence of caries of the sixth thoracic vertebra. The pregnancy was allowed to go to full term, terminating in a completely painless labor and the forceps delivery of a healthy child. A month later decompressive laminectomy was performed by Dr. Dean Lewis. She made a complete recovery and had another baby two years later.

Case IV.—*Caries of twelfth thoracic vertebra, paraplegia preceded by pains in back and legs; xanthochromia of spinal fluid; improvement following combined laminectomy and Albee operation.*

A man, 50 years old, was admitted to the hospital on January 5, 1922, on account of complete flaccid paralysis of both legs. In March, 1921, he was taken with severe pain, first in the back, then in the left hip and later in the right hip and down the legs to the knees. He was successively treated for lumbago and sciatica, but in August the legs began to grow weak and by the middle of November he was unable to walk and developed incontinence of urine. Eight years previously he had suffered from renal tuberculosis and apparently recovered.

Paralysis of the lower extremities was complete, except for very slight power of contraction in the adductors and flexors of the thighs. Pain, touch and temperature sensation was diminished, but not lost, in the area represented in Fig. 3. The tendon reflexes in the arms were normal, the abdominal and cremasteric reflexes greatly diminished, both knee reflexes and the left ankle reflex absent, the right ankle reflex barely perceptible. There was a weak plantar reflex of flexor type. There was no deformity of the spine, but a röntgenogram revealed distinct evidence of a destructive process in the body of the twelfth thoracic vertebra. The spinal fluid was yellow, gave a negative Wassermann reaction, a cell count of 8, a positive Ross-Jones globulin test and a Lange reaction in the higher dilutions (0000122321). The urine contained considerable pus. A tuber-

culin test was positive. A diagnosis of Pott's disease was made, and Dr. D. B. Phemister was called in. After some discussion the following operation was planned and performed by Doctor Phemister with the object of relieving the pressure on the cord, and at the same time, giving the tuberculous focus a chance to heal: The spinous processes of the eleventh and twelfth thoracic and first and second lumbar vertebræ were exposed, and the lamina of the twelfth thoracic removed. The dura was exposed and found to be of normal appearance. A bone transplant sawed from the crest of the right tibia was placed in a groove made by splitting the spinous processes of the exposed vertebræ. Following the operation there was urinary retention, more pus in the urine and irregular fever. A permanent catheter was inserted. Ten days after the operation slight return of motion was noted and a few days later the right ankle reflex and a bilateral Babinski reflex were obtained. In spite of a rather severe septic condition the patient gradually gained in strength and at the time of his discharge, March 28, he was able to lift his feet from the bed. The hypæsthetic area was greatly reduced as was the degree of the sensory impairment (see Fig. 4).

PRIMARY SARCOMA OF THE SPINE

As before stated, this with relative frequency involves the arches of the vertebræ, while carcinoma usually involves the bodies first.

Case V.—*Rapid onset of unsteadiness and weakness in the legs and epigastric pain followed by fever and leukocytosis, finally paraplegia.*

A girl, 7 years old, after a few days of epigastric pain became unsteady and stiff in the legs. The next day she could not walk unaided and had a leukocyte count of 13,000. The temperature was normal until the fourth day of the paralysis when it reached 101.4°. There was no disturbance of the sphincters or of sensation. When seen by me two weeks after the onset there was almost complete paralysis of both legs with bilateral Babinski sign and ankle clonus, while the knee reflexes were weak and the abdominal reflexes absent. Flexion of the neck caused pain, referred to the sternum, and the upper thoracic spines were tender, but there was no deformity. Röntgenologic examination showed a rather indefinite change, with decreased density of the fourth thoracic vertebra. The leukocyte

count was 16,700, the spinal fluid gave a negative Wassermann reaction and a cell count of five, but the Ross-Jones globulin test was positive and the Lange colloidal gold test gave a reaction in the higher dilutions as is common in the so-called compression fluid (0001122210). Two weeks later laminectomy by Dr. Dean Lewis disclosed a vascular bony tumor between the arches of the third and fourth thoracic vertebræ and beneath both of these, extending for two inches along the cord. The dura was adherent to the tumor and was not opened. Subsequently radium treatment was instituted. The tumor proved to be a giant-celled osteosarcoma. During the four months which have elapsed since the operation, there has been considerable diminution of pain and a slight gain in motion.

Case VI.—*Sarcoma of arches of twelfth thoracic and first lumbar vertebræ, paraplegia and anæsthesia from compression of cord; temporary relief from laminectomy, then recurrence and death.*

A man, 30 years old, suffered from backache, worse at night, during April and May of 1920. On May 30, the pain suddenly grew worse, and two days later his legs became weak. A month later there was complete loss of all voluntary motion in both legs, and there was retention of urine for two days, followed by incontinence. Bed sores developed. The first examination, September 16, revealed the presence of a transverse cord lesion: Complete paralysis of both legs with loss of knee, ankle, plantar and cremasteric reflexes, while the abdominal reflexes were present. Sensation was normal except for diminished heat and cold sense over the dorsum of the toes, but three days later there was loss of all sensation below the level of the distribution of the third lumbar segment (see Fig. 5). There was a hard swelling on either side of the spines of the twelfth thoracic and first lumbar vertebræ. Röntgenologic examination showed much new bone formation in the arches of these vertebræ, while the bodies appeared normal (Fig. 6). The spinal fluid was yellow, of low pressure, gave a negative Wassermann reaction, while the Ross-Jones globulin test was strongly positive and the Lange gold test gave a reaction in the higher dilutions (0012232100); cell count, 9. The blood count was normal, as was the Wassermann test with the blood. A diagnosis of sarcoma of the vertebral arches was made, and on September 21, Dr. D. B. Phemister performed

a laminectomy which revealed the presence of a nodular and lobulated tumor mass four inches in length and two and a half inches in width, involving the vertebral arches mentioned. Several large, spongy, ossified tumor masses rested on the dura. Radium was placed in the wound. Four days later the patient could move the right toes slightly and ten days after the operation he could move both feet and tactile sensation was normal everywhere. Gradually strength returned and the patient again became able to walk.

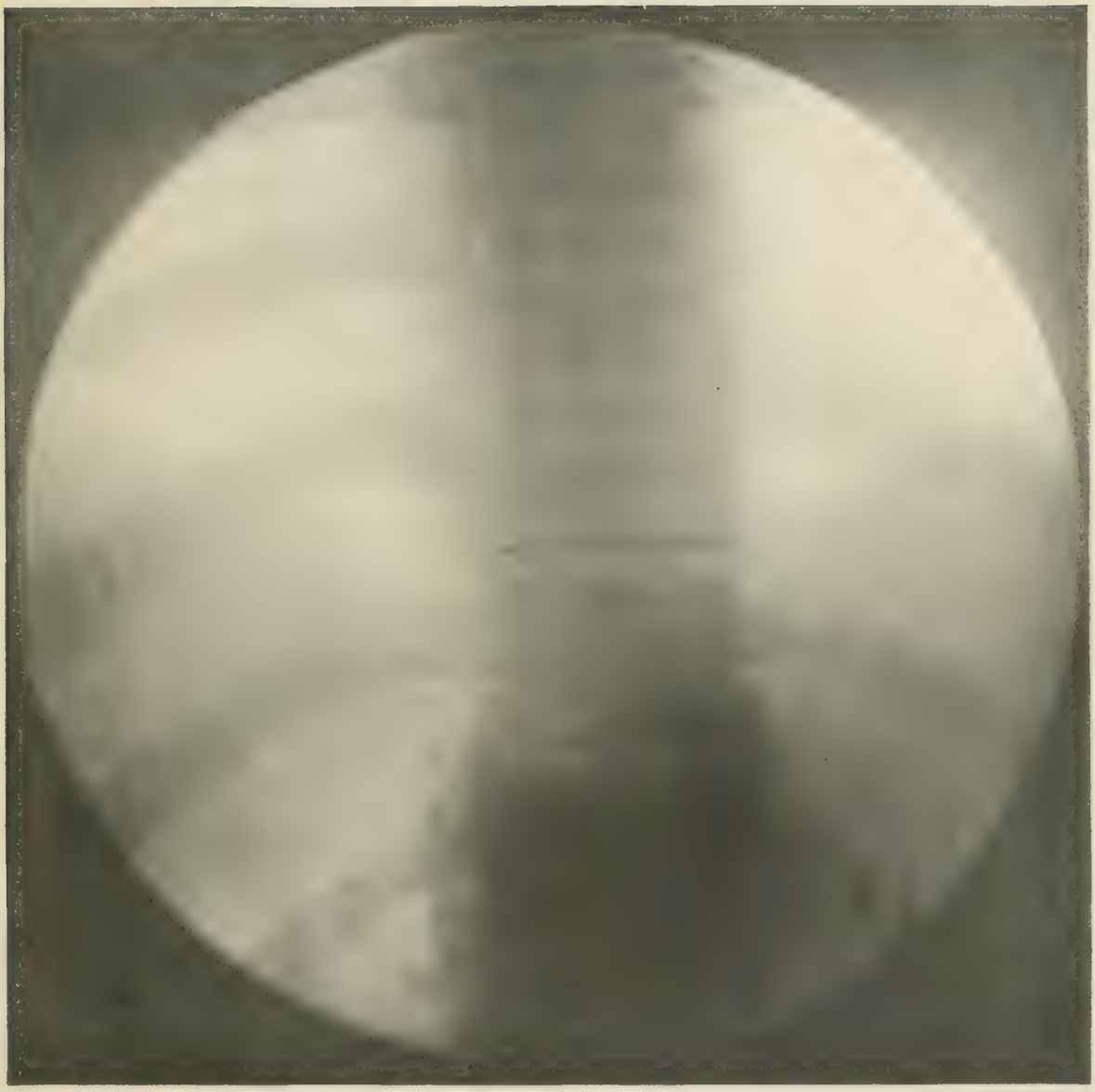
Subsequent röntgenograms in December, 1920, and February, 1921, showed the presence of considerable new bone formation on each side of the operative cleft in the spine extending upward as high as the eleventh thoracic vertebra (Fig. 7). After being able to walk for about four months the patient again became paralyzed from the renewed growth of the tumor and there were signs of metastases in the lungs. Death occurred one year after the operation.

Case VII.—*Large sarcoma of the bony pelvis with pain and weakness in the legs for several years prior to the appearance of tumor.*

A single woman, 28 years old, was admitted to the hospital July 1, 1917, complaining of pain in the region of the sacrum and coccyx, and pain in the legs on walking. This pain had been present for three years and had gradually grown worse. She had not walked without support for three months. Following a lumbar puncture made at another hospital in April, 1917, she had to be catheterized for a week. Since then there had been no bladder disturbance, except some difficulty in starting micturition. Röntgenologic examination of the spine and pelvis revealed nothing abnormal.

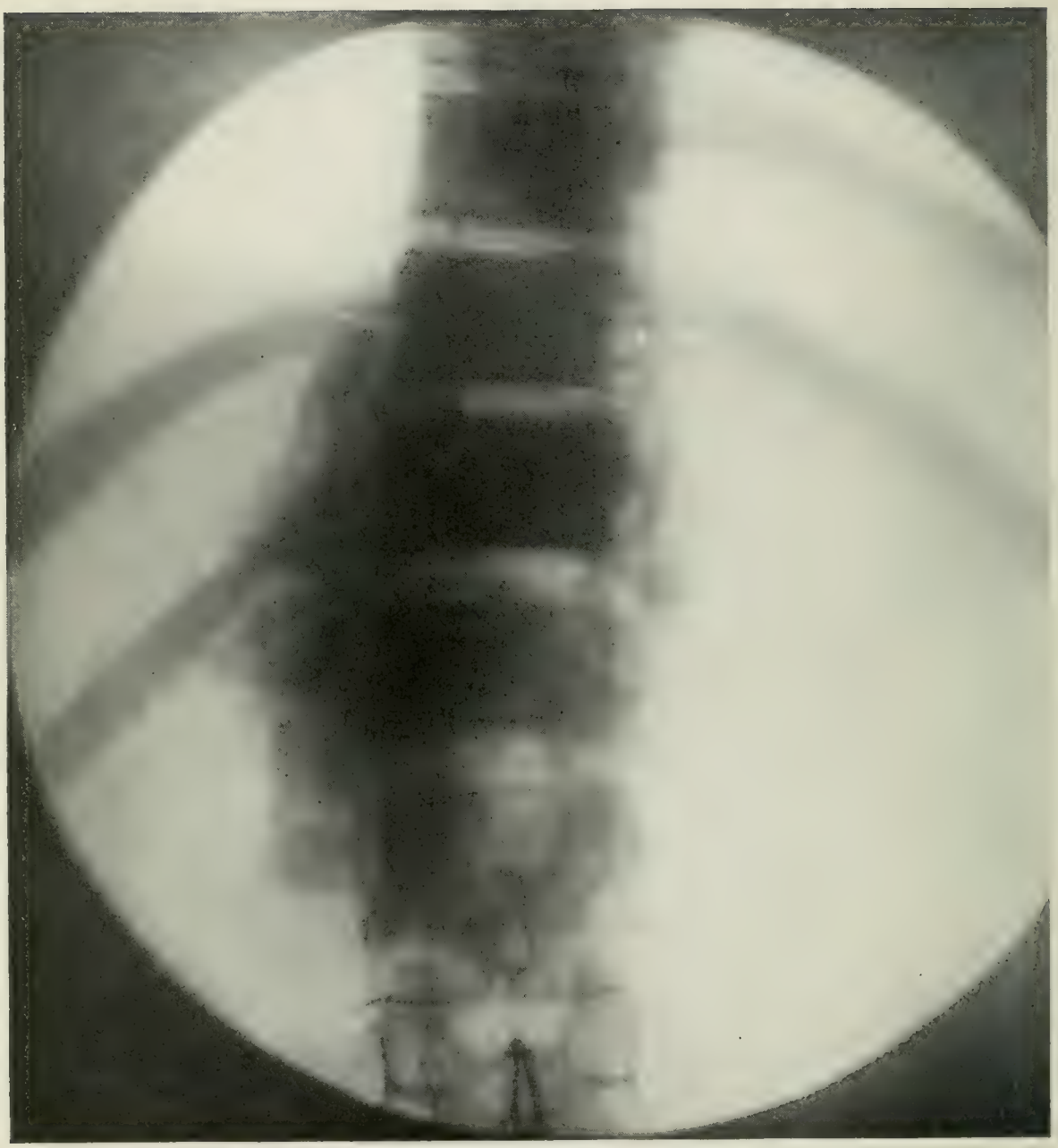
When examined on admittance, she was emaciated and weak, but there was no localized paralysis. The ankle reflexes were absent, the plantar and knee reflexes normal. The upper abdominal reflexes were present, the lower ones absent. There was hypalgesia in the posterior portion of the upper half of the left thigh and analgesia in the left gluteal region, that is, the sensory disturbance involved the distribution of the lower four sacral segments. The spinal fluid gave a negative Wassermann reaction, a cell count of 5, a strongly positive Ross-Jones test and a positive Lange test with the greatest

Fig. 6



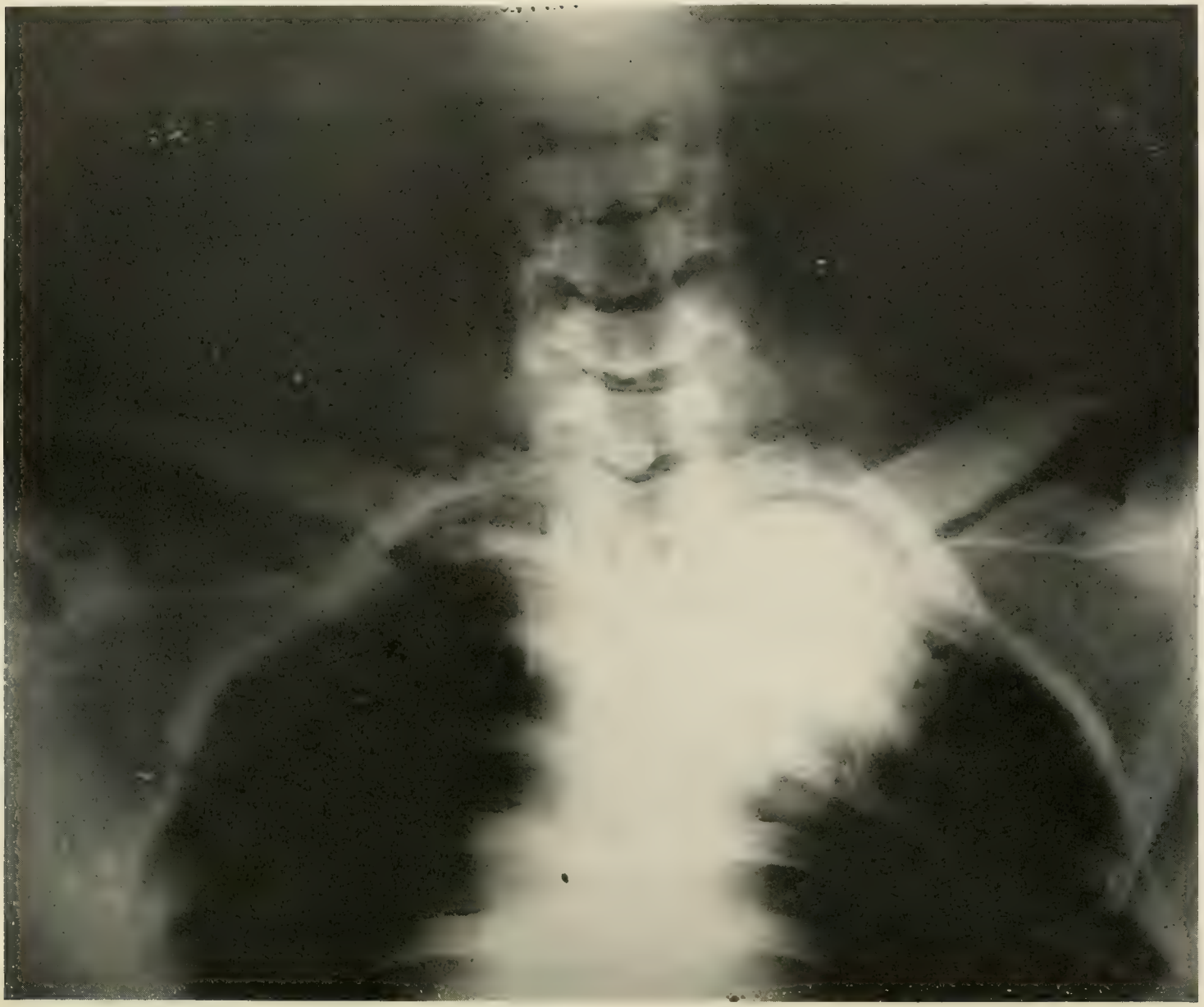
Case VI. Röntgenogram of sarcoma of twelfth thoracic and first lumbar vertebræ prior to laminectomy.

Fig. 7.



Case VI. Sarcoma of lower thoracic and upper lumbar vertebræ five months after laminectomy.

Fig. 8.



Case IX. Osteoma of body of first thoracic vertebra.

Fig. 9.

Case XI. Lipoma of cauda in case of spina bifida occulta.

reaction in the higher dilutions (2234442100). The blood count was normal.

Tumor of the cauda equina was suspected, and on July 11, Dr. Dean Lewis performed a laminectomy, removing the arches of all of the lumbar and the twelfth dorsal vertebræ, but nothing was found. When she left the hospital a month later there was no material change in her condition. Half a year later hard nodules appeared in the gluteal regions. When seen in July, 1918, the patient presented a firm tumor mass, six inches wide, over the left ilium, extending from the posterior superior spine to the median line of the sacrum, and a smaller mass on the right side. These tumors reached a huge size before the patient's death on October 3, 1918. The entire pelvis was secured as a specimen. The tumor proved to be an osteosarcoma and apparently had arisen from the sacrum. The remarkable feature about the case is the long period with purely nervous symptoms prior to the presence of the tumor becoming manifest.

Case VIII.—*"Sciatica," first in the left leg, then in the right leg; tenderness along crest of left ilium and röntgenologic evidence of erosion of the crest; rapid development of anæmia; death one year after onset; necropsy revealed osteosarcoma of left iliac bone.*

This patient, a woman of 45 years, following a fall on the ice, began to complain of pain first in the left hip, then down the entire leg. Bending of the knee gave some relief. Half a year later the right leg became similarly involved and after a few months she had to give up work. The legs, especially the right, were flabby and hypotonic. The right knee and ankle jerks were diminished, the left ones normal. All movement of the right leg was painful. There was much general weakness, but no localized paralysis and no loss of sensation. A lower lumbar scoliosis was present. There was a palpable thickening of the left iliac crest which was very tender to pressure. An incision was made, and a piece of tissue removed for histologic examination, which showed the presence of sarcoma. Röntgenologic examination showed distinct erosion of the left iliac crest; within twelve days the red blood count dropped from 3,500,000 to 1,700,000 and the hemoglobin from 45 to 25 per cent. Signs of congestion of the lungs appeared and the patient died, about 14

months after the onset of pain in the left leg. Necropsy confirmed the diagnosis of osteosarcoma of the pelvis.

BENIGN SPINAL TUMORS

Osteomas in the form of exostoses growing into the spinal canal and periosteal fibromas sometimes cause compression of the cord and their removal usually gives complete relief without recurrence. Sometimes the fibromas grow through the intervertebral spaces into the muscles and subcutaneous tissues of the back, forming visible or palpable tumors at the level of cord compression. I have in the past reported a case of such hour-glass tumor.[2]

There are also cases of tumors of the outside of the vertebræ which give rise to localized painful syndromes.

Case IX.—*Young woman suffering from neuralgic pains in arms; large osteoma of thoracic vertebra; death a few days after removal.*

A woman, 28 years old, had suffered from radiating pains in the right arm for five years. The onset was sudden following heavy lifting. The pain was steady and worse at night. Three months prior to my first examination the left arm became similarly affected. Moving the head forward and backward aggravated the pain. There was no impairment of motion and sensation and no visible or palpable bony abnormality. However, as cervical rib or cervical arthritis is always a possibility with subjective symptoms and history as presented in this case, a röntgenogram was made which disclosed a large bony mass attached to the first thoracic vertebra and projecting into the pleural cavity (Fig. 8). It was removed, but, unfortunately, the patient developed some pulmonary infection and died suddenly a week or two after operation.

OSTEOARTHRITIS OF THE SPINE; VERTEBRAL "FUNICULITIS;" "NEURODOCITIS"

Here we are face-to-face with most important problems. In what proportion are cervical, brachial and intercostal neuralgias, sciatica and lumbago and peripheral facial paralysis, etc., due to pressure on the respective nerves in their passage through bony canals and

[2] Bassoe, Peter: "Two Successfully Operated Cases of Extradural Fibroma Compressing the Cord" (Case II), *Jour. Nerv. and Men. Diseases*, Nov., 1915.

foramina? Is such pressure a more frequent cause than "radiculitis," *i.e.*, inflammation of the nerve roots at their passage through the meninges, and what is the rôle played by infectious myositis and perineuritis in more peripheral situations? There is an appalling lack of accurate data and objective observations. That all of the conditions mentioned do exist as real mechanisms is certain, but we can only guess as to their relative frequency. It would be highly desirable for pathologists to be on the lookout for anatomic data. Occasionally people die from accidents and intercurrent diseases, who have been victims of some of the neuralgias mentioned, and a great deal could be learned if advantage were taken of such opportunities. Some neurological investigators, notably Déjérine, have emphasized the rôle played by "radiculitis." Another Frenchman, Sicard,[3] considers radiculitis uncommon except in connection with syphilis, herpes zoster and certain sequelæ of acute meningitis, and lays particular stress on the importance of pressure on the spinal and cranial nerves as they pass through their foramina of exit. He designates such a bony canal a "neurodocha," and inflammation of its lining he calls "neurodocitis." He has revived the term "funiculus" for the portion of a spinal nerve lying between the junction of the ventral and dorsal roots and the point where it breaks up into branches or enters a plexus. Inflammation of this portion, "funiculitis," is a result of extension from the "neurodocitis," the latter in turn is part of an osteoarthritis or periosteal inflammatory process. According to Sicard, a tendency to contracture of the musculature in the vicinity is an important symptom of "funiculitis." This is the explanation of the stiffness of the back in Pott's disease, sciatica and lumbago. The latter he defines as bilateral, rheumatic funiculitis of the second, third and fourth lumbar nerves. If we accept Sicard's theory we have an explanation for the relief often obtained by epidural injections or injections into the intervertebral foramina, as they will reach the seat of "funiculitis" while they would not reach a radiculitis. The relief frequently obtained in sciatica from injections of salt solution in the vicinity of the nerve in the gluteal region does not necessarily upset his theory as the result may be due to relief

[3] *Presse méd.*, Jan. 7, 1918.

of secondary muscular spasms which are the direct cause of the pain by pressure on the nerve trunk.

I have become more and more convinced that a great many cases of painful shoulders and arms in middle aged people are caused by osteoarthritis of the neck and "funiculitis" rather than by arthritis of the shoulder or by toxic neuritis or neuralgia. I have repeatedly found röntgenologic evidence of such arthritis and seen relief from stretching of the neck, which automatically relieves the pressure on the funiculi. The following case is an example:

Case X.—A woman, 50 years old, last December developed severe pain in the right shoulder and arm with occasional numbness and tingling in the fingers. The neck was freely movable, but lateral röntgenograms showed marked lipping, amounting almost to bridging of the bodies of the fourth and fifth cervical vertebræ. There were no cervical ribs. An extension was applied to the head by means of a pulley and weight. The relief was marked within a few days and the pain disappeared entirely in a couple of weeks, while the ordinary anti-neuralgic remedies which had been used during the previous month had been of no avail.

Osteoarthritis of the spine may cause loss of knee and ankle reflexes, which, with the accompanying pains, may simulate tabes. Babinski, in 1903, described such a case as "pseudo-tabes spondylosique," but the rigidity of the spine led to a correct diagnosis. A similar case was recently reported by G. Ganter.[4]

Eleven years ago Pearce Bailey and Louis Casamajor[5] discussed osteoarthritis of the spine as a cause of compression of the cord and spinal nerves, and the relief occasionally obtained by laminectomy.

CONGENITAL VERTEBRAL MALFORMATIONS

I. *Spina Bifida Occulta.*—This is most common in the lumbosacral region and its presence is frequently revealed by a depression above the anus (fovea coccygea), usually with a tuft of hair projecting from it. The invisible bony cleft is only of importance as indicative of associated malformations of the spinal-cord. This so-called myelodysplasia has been particularly described by Alfred

[4] "Revue Neurologique," February, 1920.

[5] *Jour. Nerv. and Men. Dis.*, October, 1911.

Fuchs[6] and further elaborated by William G. Spiller.[7] That this condition may exist in many members of a family has been shown by D. Jancke.[8] When symptoms are produced, nocturnal enuresis is particularly frequent and there is often more or less marked talipes. Paralysis of the legs may appear after puberty as the result of traction on the cauda equina or cord by the "membrana reuniens" which fails to grow in proportion to the spine. In other cases progressive symptoms result from associated tumor growth, particularly lipoma. On account of these possibilities William Brickner[9] advises operation in all cases in children with congenital lipoma or hypertrichosis whether there are symptoms or not, and in adults in the presence of symptoms. He adds five to the twelve previous reports in the literature of such operations, all without fatality and with decided benefit.

A. Lichtenberg[10] attempts to segregate those cases of nocturnal enuresis which are dependent on sacral defect malformation. In such cases there has usually been an interval between earlier incontinence and that appearing about the age of ten years. There is also a tendency to diurnal incontinence. Some residual urine is present, and the bladder is hypertrophic and trabeculated. The typical skin changes are present over the sacral cleft. In one of the two cases operated upon by the author, success was attained. The adhesions between the dura and the edge of the cleft were separated and the cleft was closed by a transplant from the tibia. The following case illustrates how a person may succumb in middle life to the secondary effects of such malformations.

Case XI.—*Lumbosacral spina bifida occulta and slight congenital talipes; after age of 50 progressive symptoms resembling those of syringomyelia; finally urinary retention, pyelonephritis and death; necropsy.*

A clergyman, 52 years old, aside from a mild form of congenital talipes (pes cavus), had no symptoms until the fall of 1911, when numbness of the feet and precipitate micturition appeared. My

[6] *Wiener med. Woch.*, 1909, p. 2141.
[7] *Amer. Jour. of Med. Sciences*, April, 1916.
[8] *Deutsche Zeitschr. f. Nervenheilk*, December, 1915.
[9] *Amer. Jour. of Med. Sciences*, April, 1918.
[10] *Zeitschr. f. urolog. Chir.*, June, 1921.

first examination, in January, 1912, revealed absence of both ankle jerks and of the left knee jerk, bilateral Babinski sign, and loss of pain and temperature sensation in the gluteal region and part of the legs, namely, in the distribution of the fifth lumbar and all sacral roots. There was a dimple with a hairy tuft above the anus and the röntgenogram showed a cleft in the arch of the fifth lumbar vertebra. In January, 1916, he returned to the hospital with severe pyelonephritis and died in a few days. At necropsy there was found a marked bulb-like enlargement of the conus, the enlargement being due to a large lipoma (Fig. 9). A glance at the cross-sections (Fig. 10 and 11) shows the great distortion of the cord structure, particularly in the posterior portion which merges into an irregular mass of medullated fibres attached to the lipoma. The two cross-sections showing the distribution of the ascending degeneration in the lumbar and cervical portions of the cord are also of interest, as they show us the location in the cord of the fibres from the affected region (Figs. 12 and 13).

As compared with posterior clefts, spina bifida anterior is rare. It has recently been discussed by W. Altschul.[11] Very uncommon are defects of this kind in the upper portion of the spine. I once observed a girl, 13 years old, who was brought to my clinic on account of clumsiness and slowness of the finger movements. There were no objective signs except a hyperextensibility of the finger joints and the pathognomonic sign of a dimple and hairy tuft in the median line at the back of the neck. This case has been reported by my then associate, Samuel N. Clark.[12]

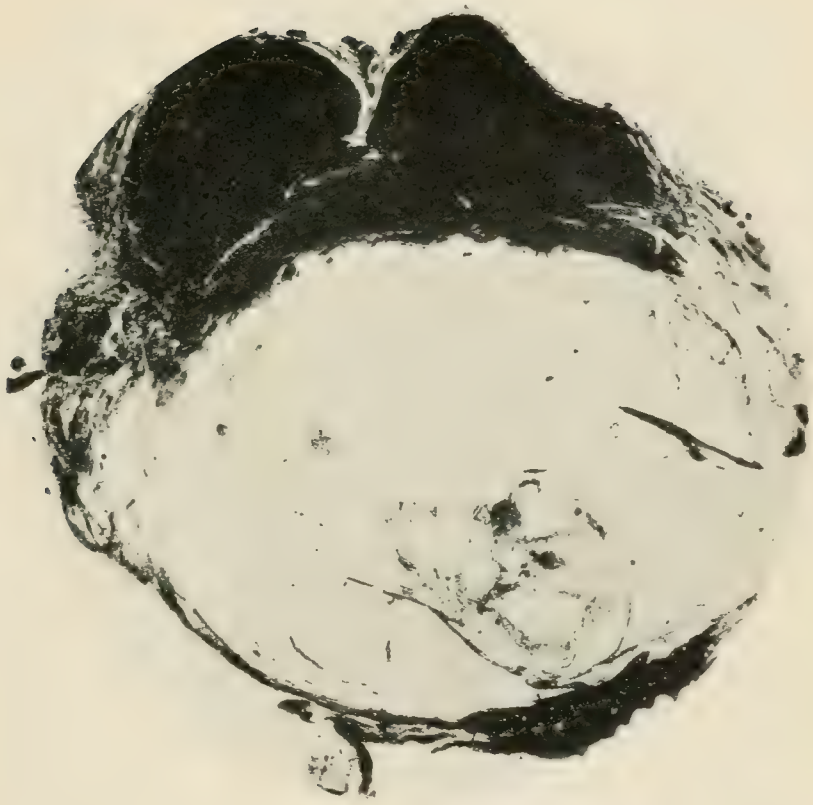
II. *Regional Vertebral Heteromorphisms.*—Under this heading we will include various congenital alterations of the vertebræ which must have arisen on account of some altered mechanical conditions in fœtal life. They are met with at the junctions of vertebræ of different types and consist of the assumption on the part of a certain vertebra of characteristics belonging to the vertebræ immediately above or below it. Following A. Roccavilla[13] we may enumerate the principal forms as follows: "Occipitalization" of the atlas with development of lateral masses; "dorsalization" of the seventh cervical vertebra

[11] *Fortschr. a.d. Gebiet. d. Röntgenstrahlen*, Feb. 24, 1921.

[12] *Jour. of Nervous and Mental Dis.*, September, 1918.

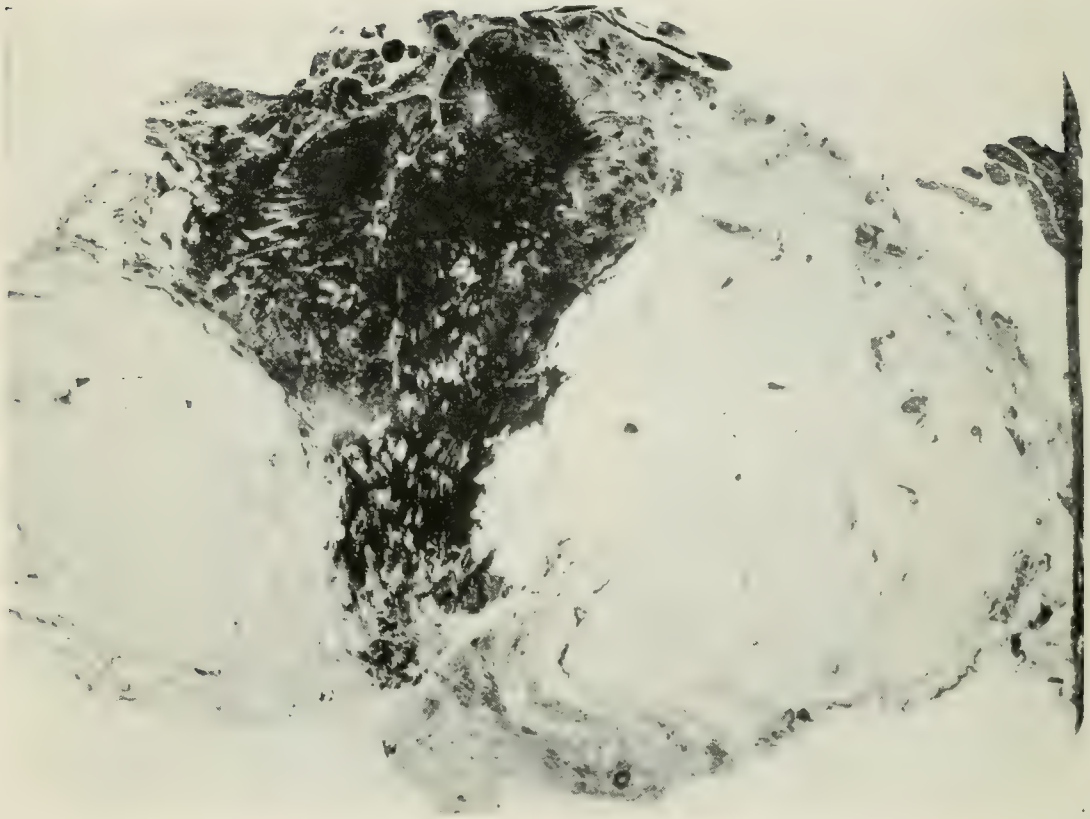
[13] *Rev. Neurol.*, January, 1921.

Fig. 10.



Case XI. Cross-section of lipoma of conus. Pal-Weigert stain.

Fig. 11.



Case XII. Cross-section of lipoma of conus. Pal-Weigert stain.

Fig. 12.

Case XI. Lumbar cord (Pal-Weigert stain), showing ascending degeneration of posterior columns.

Fig. 13.

Case XI. Cervical cord (Pal-Weigert stain), showing ascending degeneration in median portion of posterior columns.

Fig. 14.

"Sacralization" of fifth lumbar vertebra with symptoms of ureteral calculus.

Fig. 15.

Case XII. "Sacralization" of fifth lumbar vertebra with clinical picture of sciatica.

with formation of cervical ribs, and of the first lumbar vertebra with formation of lumbar ribs; "sacralization" of the fifth lumbar vertebra and of the coccyx; "lumbarization" of the first sacral segment, and, finally, "coccygeal paramorphosis" of the last sacral segment.

The symptoms of cervical ribs are too well known to discuss here, and lumbar ribs rarely cause symptoms. "Sacralization" of the fifth lumbar vertebra is a topic much contested at the present time, especially in connection with so-called "low back pain." With "sacro-iliac slipping" it shares the honor of being the subject most prone to arouse an animated discussion at meetings of orthopedic surgeons. According to Roccavilla, when the fifth lumbar vertebra is sacralized, it becomes flattened and surmounts the sacrum like a dome. Its spinous process is shortened and fused with the sacral crest, while one or both of the lateral processes elongate so as to reach, or even pass beyond, the borders of the iliac bones and wings of the sacrum. A new bony canal may form by the apposition of the sacro-iliac groove below and the groove between the elongated transverse process and its vertebral body above. The sacralized fifth lumbar vertebra usually retains its mobility, though it may touch the ilium, as there are no prepared articular surfaces on this bone. However, if sacralization is complete, the transverse process becomes fused with the ilium and in this case the fifth lumbar nerve is in danger of compression, traction, and even laceration on account of its ill-fitting bony canal.

The nervous symptoms may consist of simple lumbago, or of attacks of lumbosacral pain with rigidity. The pains may extend in girdle manner around the abdomen, along the ureters, along the spermatic cords to the testicles or along the round ligaments to the labia majora. An erroneous diagnosis of renal or vesical calculus, pyelitis or cystitis is sometimes made. With the main affection of the fifth lumbar and first sacral nerves, pain occurs in the distribution of the sacral plexus, including the sciatic nerves.

In looking over röntgenograms taken for various purposes in which sacralization was accidentally discovered, I encountered two cases in which calculi in the urinary tract had been suspected. In one of them the symptoms were so suggestive that an operation for suspected ureteral calculus was performed as a small, suspicious

shadow had been seen in the course of the ureter. However, it turned out to be a phlebolith, so the only positive pathology remaining was the sacralization (Fig. 14). I will not venture a definite opinion as to whether or not this was the real cause of the symptoms. In the following case the relation of sacralization to the symptoms appears fairly definite.

Case XII.—A married woman, 22 years old, in the second month of pregnancy, had been suffering from right-sided sciatica for nearly three months. She presented the usual signs of sciatica and in addition there was tenderness on the anterior surface of the thigh. The tendon reflexes were normal. Röntgenograms showed typical sacralization of the fifth lumbar vertebra (Fig. 15). She was given several perineural injections of salt solution with very good results. It would appear reasonable to suppose that the vertebral malformation may have been at least a factor in causing irritation of the fifth lumbar nerve, which helps in forming the sciatic nerve. The resulting rigidity of the deep gluteal muscles was probably the direct cause of the pain along the sciatic nerve, otherwise the injection would not have been likely to give such prompt relief.

In severe cases of sacralization various operations have been performed, such as sawing off the elongated transverse processes, or immobilizing them by fastening them to the ilium, or removing bone to enlarge the foramina for the nerves. As far as I have been able to learn, the results have been rather meagre, though I have personal knowledge of success in a few cases.

THE BILIARY TRACT AND TYPHOID INFECTION*

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TWENTY years ago comparatively little was known about the true infective nature of the typhoid bacillus for, as ordinarily inoculated, it usually failed to produce in the lower animals any series of symptoms or any lesions comparable to those of typhoid fever in the human being. It was then stated that the bacillus infected the individual through the intestinal tract, in association with lesions in Peyer's patches, of the spleen and of the mesenteric glands. These facts were emphasized, and little else was thought of its invasions into neighboring and important organs.

As early as 1850, Greisinger announced from Cairo an infectious febrile disease undoubtedly often brought about through the bacillus typhosus and to which he applied the name "typhus biliosus," which may or may not be the same disease as we recognize under the names of acute infectious jaundice, infectious febrile ictrus, bilious typhoid and Weil's disease.

Be this as it may, we now know that the biliary passages are the seat of many micro-organisms, principal among which are the bacillus coli communis and the bacillus typhosus. Many distinguished authorities, backed by Hoppe-Seyler (1903), declare that normal bile in normal bile-passages is always sterile; while Lippman (1904) and Bond (1905), independently of each other, proved conclusively that it is possible to find bacteria in normal bile and in normal bile passages, while John B. Deaver asserts that "In our own experience cultures from the biliary tract taken at operation proved sterile in over 55 per cent. of the cases examined." The Mayos refer to the paper of Lartigau (New York Academy of Medicine, 1902) for their assertion: "Healthy bile always contains a moderate number of bacteria."

How these bacteria gain entrance to the biliary tract is a moot question.[1] Is it through the portal circulation, or the symtemic cur-

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[1] Many of these statements are based on the brilliant and elaborate studies of the late Dr. A. O. J. Kelly, taken from the Mütter Lecture of the College of Physicians, Philadelphia, 1905.

rent, through the duodenal opening of the common bile-duct or through the lymphatics? There is more than a possibility of their invasion *through the walls* of the biliary tract.

The usual pathway of bacterial entrance in cases of biliary infection is through the portal circulation. Adami has shown that normally bacteria may be found in the deeper layers of the intestine, the portal circulation and in the liver, believing that the leucocytes carry bacteria to the lymphatic radicles and also to the radicles of the portal vein. It is just in this way that appendicitis, typhoid fever and other infections in the abdomen may predisposingly favor infections of the biliary tract.

Normally, the liver cells offer a triumphant resistance to a variety of germs that make their way there through the portal circulation, but with impairment of these cells, many of these micro-organisms escape destruction and are excreted with the bile. The fact that the bacillus typhosus is quite frequently found in the biliary tract and that biliary affections are not infrequently found in association with typhoid fever, is incontrovertibly due to infection being carried through the systemic circulation. The presence of the typhoid bacillus in the gall-bladder unassociated with other bacteria quite strongly established this fact. Again, the researches of Joseph Koch, Wrzosek, Else and Rosenow all confirm the presence of infection carried to the liver through the general circulation. In 1914, Rosenow announced the results of his studies of bacterial invasion of the abdominal organs, asserting that certain colonies showed a predilection for the pylorus, others for the appendix, others for the biliary passages; although the healthy duodenum, when free of all food, is almost free of germ life.

The first impetus to a thorough understanding of the subject under review was given when Mason, a quarter of a century ago, detailed at great length the complications of typhoid fever. His studies were eagerly taken up by others in the field and as a result of these labors, the following deductions have quite unanimously been arrived at: " (1) That the typhoid bacillus is regularly present in the gall-bladder, and commonly in pure culture, in practically all cases of typhoid fever—indeed, it is one region of the body from which a pure culture of the organism is most likely to be obtained. (2) That the typhoid bacillus may persist in the gall-bladder as well as within gall-stones, weeks, months, even years after the patient has recovered

from an attack of typhoid fever. (3) That cholangitis and cholecystitis (catarrhal, suppurative, and gangrenous) are by no means infrequent complications of typhoid fever. (4) That a history of antecedent typhoid fever may be obtained in many cholelithic and cholecystic subjects." (A. O. J. Kelly.)

In cases of typhoid fever, Kelly advises "systematic and repeated examinations of the gall-bladder region," in order to ascertain any distention or inflammation of that organ, for it must be remembered that the quantity of bile discharged into the duodenum is dependent upon varying factors. Thus, when unneeded for digestive purposes, the bile backs up through the cystic duct into the gall-bladder. Now we well know that the diet of the typhoid patient is largely restricted and as a rule little of a digestive process is called into play to act upon the bland nutriment prescribed by the attending physician, in consequence of which bile is not required and, as a result, the gall-bladder becomes distended and intimately intermixed with a large quantity of mucus. If the quantity of mucus be of sufficient volume, it will act as a plug to the cystic duct, and the stagnant bile will attract to itself many bacteria, both innocuous and noxious. The multiplication of these germs will thus result in inflammation. Because of the pain present in the dominating disease, the patient is unaware of the liver involvement and, hence, the wisdom of repeatedly examining the liver and the gall-bladder in order to recognize as early as possible any inflammation of the biliary passages.

It is an undecided question whether or not gall-bladder and other biliary conditions are at all aggravated by the presence of typhoid fever. Up to the present time, no definite or special contribution has been forthcoming to assert that in cases of cholelithiasis, any marked inflammatory changes have been added to the usual clinical picture presented.

Statistics are unavailable showing the frequency of gall-bladder involvement and enteric fever. A. P. C. Ashhurst analyzed the reports of the Episcopal Hospital, Philadelphia, 1908, and found that among 2864 cases of enteric fever there were but 18 (0.62 per cent.) in which infection of the gall-bladder was recorded as a complication. Quénu, in 1908, collected 45 operations for lesions of the gall-bladder during or soon after the onset of typhoid fever. Thomas reports a study of 154 cases of cholecystitis of typhoidal origin and

says perforation occurred in thirty-nine instances (25.3 per cent.). Eleven of these patients underwent operation with a resulting mortality of 54 per cent. The remaining 28 died without operation. The bacillus typhosus was isolated in just one-half (50 per cent.) of the cases that went to operation; calculi were found in three instances.

With these prefatory thoughts relative to the likelihood of association of typhoid fever with affections of the biliary tract, the questions naturally arise, (1) do these cases always exhibit much the same symptoms, and (2) should operation be immediately resorted to? Many surgeons classify these cases of gall-bladder disease during the course of typhoid fever as of two varieties: That class where the onset of the symptoms is more or less insidious and manifest by a localized pain in the right hypochondriac region, in association with some tenderness in the location just mentioned and the frequent recognition of a palpable mass—a distended gall-bladder. (A cholecystitis or empyema of the gall-bladder.)

In the second class of cases, the above symptoms have existed from 12 to 24 hours, or for days or a week, when suddenly the pain becomes agonizing and there is a rapid decline in temperature. When operation is not immediately undertaken, the temperature quickly mounts to 102 or 103°, with a diffusion of pain over the entire abdomen, the abdomen at the same time becoming extremely tender and giving the appearance of marked distension.

The question often arises should operation be resorted to when cholecystitis is seen as a complication of or in association with typhoid fever? The unhesitatng answer is "no"; but if the existence of empyema is demonstrable or if perforation is imminent, then cholecystostomy becomes an imperative necessity. On the other hand, no time should be lost to operate in detecting a perforation and, in the vast majority of cases, cholecystectomy is the operation of choice. If, however, the cholecystitis gradually ameliorate and yield to the remedial measures that the ingenuity of physician or surgeon may devise, the case should not in any way be interfered with, but the patient, after recovery from the typhoid infection, should be held under surveillance, for in all probability, at a little later period, the development of cholelithiasis will be evidenced.

Another matter of compelling interest is the peculiarity of certain persons to "harbor" the typhoid germ. *Per contra,* it would seem that a certain immunity is acquired by habitual exposure to the

bacillus in a not very virulent form. There would appear, also, to be an hereditary susceptibility or lack of susceptibility to the attacks of the germ, as certain families are especially prone to be attacked while others escape through successive generations. The late Dr. William Pepper, of the University of Pennsylvania, believed that intestinal catarrh and catarrhal conditions of other organs, strongly predisposed by affording a nidus of growth to the organism. Again, Peters pertinently asks: "How comes it that when a million of people are drinking the infected waters of the Seine, only a comparatively few are affected?" So, while we must recognize there are those who are quite immune to the germ, on the other hand, there are those who are most susceptible to it.

It is in this latter class that typhoid infections of the biliary tract are to be suspected and so frequently are revealed. Such individuals are often referred to as "typhoid carriers." The "typhoid carrier" may show many and varied affections, be it in the liver or in the gall-bladder or in some remoter organ without the development of actual typhoid fever. It is for this reason that many of the best thinkers in the profession, led by Quénu, assert that the term typhoid fever may be a faulty one, but the expression enteric fever is just as erroneous, because it has been shown that the bacillus is carried by the blood to the liver and its elimination by that organ sets up a septic condition in the bowel. Thus, the liver is the primary agent for the dissemination of the toxin or toxins and, while the eliminant may affect the bowel and its associated lymphoid structures and give rise to typhoid fever, it may (as earlier noted in this paper) infect the bile and give rise to numerous affections, among which we especially cited the "typhus biliosus" of Greisinger, of 1850, latterly designated as infectious jaundice, bilious typhoid and Weil's disease, and yet the patient be entirely free of typhoid fever.

Just the same as a person may be a "carrier" of ivy poison and yet not "take it" it, so with the "typhoid carrier." There are many cases cited in medical literature where these persons had never contracted the disease, or had never manifested any affection of any viscera and yet were capable of spreading the affection far and wide and contaminating milk and many other articles of food, especially when employed in handling and purveying such aliment.

In the instances of "carriers," the bacillus typhosus is often found latent in the liver, the gall-bladder and the bile. This has

been indubitably revealed at autopsy in a large number of cases. As before intimated, these persons may offer nothing abnormal except in the discovery of the bacillus in the stools or duodenal contents of the "carrier." Presence of the bacillus in the duodenum points to the likelihood of typhoid infection of the biliary tract. The method of treatment to be invoked in this class of persons is cholecystectomy *with drainage of the hepatic duct.* Hepatic-duct drainage is imperative for the best possible results. Its introduction in connection with cholecystectomy is due to Kehr, who announced this supplemental procedure in 1913. Prior to that time, the operation of cholecystectomy, without the additional drainage just mentioned, at times failed of success.

The following interesting resumé of this class of cases is thus reviewed by Deaver in his large experience at the Lankenau Hospital, Philadelphia:

"Among a series of eighty-one patients at the Lankenau Hospital, with a history of antecedent typhoid infection, the contents of the gall-bladders were examined bacteriologically in forty-six; of these, thirteen cases, or 28.4 per cent., gave cultures of the bacillus typhosus. It cannot, however, be stated positively that none of the remaining sixty-eight cases should be classed as sequels of typhoid fever, since these might be cases in which the gall-bladder had rid itself of the bacillus typhosus after this infection had caused structural changes, the deposition of concretions, etc. In fifteen, or 32.6 per cent., of the forty-six examinations, pure cultures of the colon bacillus were found. Here again, it is uncertain whether these cases should be classed as sequels of the antecedent typhoid, or as cholelithiasis resulting from the invasion of the gall-bladder by the colon bacillus; but we believe that the calculous formation, in these cases, with possibly few exceptions, was a direct result of the pathological changes consequent upon the typhoid infection."

In conclusion it is interesting to note that this subject is now being thoroughly investigated, especially is this true in many foreign countries. Throughout the British Empire the subject has evoked much recent study and much discussion. In Germany many clinicians of late distinguish between typhoid fever and the typhoid secondary to biliary antecedent, which they designate "biliary typhoid."

THE GASTRIC DISTURBANCES OF OLD AGE *

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THE gastric affections of old age are worthy of the most earnest consideration. It is in old age, that is, after the sixtieth year, that there is a general tendency towards a development of certain forms of dyspepsia differing in many respects from those occurring in younger individuals. It is only by means of a comprehensive study of these conditions, that the various factors, leading to the development of senile changes can be definitely determined, and thus much may be accomplished by the early recognition of such influences in the prevention and amelioration of these diseases, and possibly in the prolongation of life.

It is towards the end of middle life and in old age when the most serious form of gastric disturbances begin to manifest themselves frequently appearing with symptoms so mild and insignificant that their importance is very often overlooked until late in their course; often only after alarming signs have already developed. Many of these disorders have their origin in youth, at that period usually in an apparently unimportant form, while others drag along, from youth to old age with exacerbations and remissions, only presenting serious manifestations often in middle life and old age when the transition from benign to malignant states is so commonly noted.

In comparing the gastric disorders of youth and old age, one is at once impressed with the fact that the acute types are more frequently observed in the young, while the more chronic forms are more usually seen in adults. This may be due to the fact, that the causative factors leading to the disease have not been sufficiently potent to as yet make serious inroads into the patient's health, until the influence has become so prolonged as to produce organic manifestations.

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Of the various factors concerned in the etiology of the gastric affections of old age the following are especially to be noted.

1. Indiscretions in diet.
2. Influence of diseases of other organs beyond the stomach itself.
3. Infectious diseases.
4. Focal infections.
5. Degenerative changes.
6. Arterio-sclerosis.
7. Syphilis.
8. Toxæmia.
9. Disturbances of the nervous system.

(1) INDISCRETIONS IN DIET

Habitual indiscretions in food and drink in addition to the abuse of tobacco are often potent factors in the production of the gastric disturbance of old age. In this group the various forms of chronic gastritis and hyperchlorhydria are especially to be noted.

In an analysis of 542 cases of hyperchlorhydria studied by us, 186 cases were brought about by these conditions of which 34 or 18 per cent. occurring between the ages of 50 and 70 years.

The following table of Fenwick presents the relative frequency in the production of chronic gastritis by errors in food and drink.

Alcohol	60.0 per cent.
Errors of diet	17.9 per cent.
Drugs	13.3 per cent.
Tobaccco	8.8 per cent.

(2) DISTURBANCES OF THE STOMACH DUE TO DISEASES OF OTHER ORGANS

In a study of the gastric affections of old age it at once becomes apparent that in a large proportion of instances disturbances of the gastric functions are encountered as the result of disease of other and often distant organs. At times, in fact, especially in the more chronic cases as well as in the febrile forms, the gastric symptoms may present the most marked features while the actual disease producing the gastric disturbance is only recognized with difficulty and on this account errors in diagnosis not uncommonly occur.

According to W. Fenwick, of every 100 cases of chronic dyspepsia in individuals over 65 years of age, 66 per cent. are secondary to

organic disease of some important organ, while but 34 per cent. are due to progressive degenerative changes of the stomach and intestines.

The cause of the disturbed stomach functions lies either in some disturbance of the circulation, nervous system or to some form of toxæmia.

In diseases of the heart and liver, portal obstruction is a frequent cause of the gastric disturbance; in nervous affections there is frequently an alteration of the gastric secretion, while in febrile states, kidney disturbances, tuberculosis, diabetes and anæmia, changes in the gastric mucosa may occur, due to toxæmias often specific to the individual disease.

In many instances the gastric disturbance is observed as a purely nervous manifestation such as we not infrequently note in the form of pylorospasm in instances of chronic appendicitis, and in cardiospasm in gall-bladder affections.

Among the diseases most frequently noted as affecting the gastric functions during old age are disturbances of the intestine, lung, heart, liver, genito-urinary organs as well as the various forms of anæmia; diabetes and nervous diseases.

(3) INFECTIOUS DISEASES

Beaumont first called attention to the fact that in febrile states there is a diminished secretion of gastric juice with a resultant lowered gastric digestion. It is therefore not uncommon to observe symptoms of indigestion accompanying many of the infectious fevers occurring in old age.

The symptoms of dyspepsia are more pronounced in certain of these affections than in others; for example, one commonly finds gastric upsets in the form of nausea, vomiting, and distention, in pneumonia, influenza and tuberculosis. In these infectious fevers the appetite is always diminished and in many instances there is marked anorexia. The symptoms of indigestion may not only exist during the entire course of the fever, but may continue on during the stage of convalescence.

Gastritis may be produced both directly and indirectly by infections. Thus thrush due to the growth of schizomycetes may extend into the stomach directly developing as a part of the general infection. Rosenheim has reported a case of this disease associated

with violent gastric symptoms in a woman of 60 years. Dieulafoy has also called attention to certain unusual cases of pneumonic infections of the stomach leading to gastritis and ulcerations.

Finally, it is important to note that the rôle played by infectious diseases in the production of gastric disturbances is not only important on acccount of the immediate effect, but that long after the infection has disappeared definite gastric manifestations may still remain as the result of the inroads made by the infection upon the stomach.

(4) FOCAL INFECTIONS

It is a well-established fact that focal infections may play an important rôle in the production of certain gastric disorders of old age. The primary focus may be localized in the various portions of the body, as in the teeth, tonsils, sinuses, gall-bladder, appendix, intestine, genito-urinary tract or other organs. It is generally admitted, for instance, that a certain proportion of ulcerations are produced as a hematogenous infection, with a special strain of streptococci absorbed from certain foci of infection. The method of production of the ulceration is an infection of an embolic streptococci type in the submucous layers of the stomach with the production of hemorrhagic areas in the surrounding tissue; in consequence of which anæmic necrosis takes place followed by the digestion of the mucous membrane above by the gastric secretion. Depending upon the extent of the infection either healing may take place or chronic ulceration may ensue.

(5) DEGENERATIVE CHANGES

The degenerative changes of old age are observed in the form of weakness in the muscle fibres of the stomach, giving rise to atony, to a diminution of the gastric secretion and atrophy of the mucous membrane. Due to these degenerations there occurs a weakened motility of the stomach with retention of its contents together with a decrease of digestive power.

These changes frequently lead to the most distressing gastric symptoms, often so severe as to simulate malignant disease. The symptoms arise, however, as a rule far more gradually, and frequently extend over a long period of time.

Fenwick has graphically described the progressive degenerations affecting the secretory structure of the digestive tract in advancing

years. He points out that although after the age of fifty these changes are quite constant, careful observation will frequently reveal their presence at a far earlier period of life, even at times at the age of forty.

Microscopically, the pyloric end of the stomach appears attenuated, the rugæ no longer being marked and the mucous membrane appearing very smooth, pigmented and adherent to the adjacent muscular layer. The pyloric orifice is somewhat contracted.

On microscopic examination, the pyloric area presents an increase in connective tissue, which surrounds the tubular glands, resulting in their attenuation. In the earlier stages of the disease one observes that the columnar epithelium covering the surface of the mucous membrane and of the ducts has disappeared and that the cells of the glands no longer present their normal outline, but are granular in appearance.

In a more advanced stage the continued growth of the connective tissue compresses and distorts the glandular structure until nothing but minute cysts remain. These finally disappear and the mucosa is converted into a thin layer of connective tissue.

While these changes are progressing in the mucous membrane the submucous layer becomes affected with a similar but less marked form of connective tissue change associated with an obliterative endarteritis and as a result the intervening muscularis mucosa is destroyed due to compression.

At the onset the muscular coat presents signs of hypertrophy, but finally interstitial changes manifest themselves and the muscle fibres undergo fatty degeneration or atrophy. These connective tissue changes are rarely observed beyond the central zone of the stomach.

At times degenerative changes are observed in the vessels of the stomach itself, leading to rupture with hemorrhages of a more or less severe type, which is not infrequently most difficult to distinguish from those occurring in ulceration. The degenerative changes having their origin in middle life are usually mild and often progress extremely slowly so that they may be entirely overlooked until the onset of old age when they then become more fully developed.

(6) ARTERIO-SCLEROSIS

Arterio-sclerosis is a most important factor in the production of the gastric disturbances of old age. It is observed in one of two distinct varieties.

First, those forms in which the arterio-sclerotic changes are primarily in the stomach itself.

Second, those in which the manifestations are secondary to a general arterio-sclerosis. Both conditions exert an important rôle as factors leading to gastric symptoms of varying degrees.

Due to the primary changes in the media and adventitia there, is a thickening of the intima which finally involves the media and adventitia. Harlow Brooks has called attention to the fact that the disturbed visceral function with occasional elevation of blood pressure which cannot otherwise be accounted for should lead to the suspicion of some localized area of arterial disease and especially when associated with anginal pain located in the stomach.

As a result of the arterio-sclerotic changes a definite form of abdominal angina may be produced, associated with paroxysmal attacks of pain of a rather severe type. Attention has already been directed to the gastric hemorrhage not occasioned by ulceration but produced by degenerative changes in the vessels of the stomach.

A frequent cause of these hemorrhages is found in the miliary aneurysms due to arterio-sclerosis of the small gastric arterioles.

As arterio-sclerosis plays an exceptionally important rôle in the production of the gastric disturbances of old age this condition will again be more fully considered.

(7) SYPHILIS

Syphilis of the stomach is not an infrequent affection in old age. In the largest proportion of instances the cases have occurred during the tertiary stage of the disease, though secondary syphilis is frequently accompanied by symptoms of indigestion due as a rule to a toxæmic gastritis. Tertiary syphilis may, according to Fenwick, appear in three forms as (1) gummatous formations; (2) in the form of endarteritis, and (3) as chronic inflammation of the mucosa.

(1.) Large gummata have not been frequently noted in the stomach, Chiari having observed but three instances of this affection.

(2.) Obliterative endarteritis occurring in the blood vessels of the stomach is frequently noted in syphilis, though it need not necessarily be indicative of the presence of the disease, for it may occur as well in simple ulcerations and in arterio-sclerosis. Syphilitic endarteritis is usually associated with gummata in the liver, spleen, and

pancreas and frequently affects the minute branches of the pyloric vessels in the submucous and subserous connective tissue; as the result of the interference with the nutrition of the wall of the stomach, ulceration may ensue.

(3.) Chronic gastritis. Chronic gastritis may occur as a direct or indirect effect of syphilis. As a result of the interference with the circulation of the stomach from luetic disease of the liver, spleen, kidneys, etc., a secondary gastritis may be induced. In the luetic gastritis, the mucous membrane is dull and opaque and is usually thickened due to an increase in the connective tissue between the glands. The gastric glands are frequently observed to be distorted and disorganized by a round cell infiltration, which is usually profuse in the submucosa and glandularis. In consequence of the cicatricial contraction about the pylorus, stenosis with gastric dilatation may occur.

(8) TOXÆMIA

Toxæmia associated with gastric disease is not uncommon in old age, and may be either of exogenous or endogenous origin.

The exogenous forms are caused by the ingestion of concentrated mineral acids and alkalies, by such poisons as phosphorus and arsenic, and by food infected with certain pathogenic micro-organisms.

Due to the toxic substances an intense inflammatory state of the stomach is produced which is more severe when the poison is swallowed in the fasting state. The parts affected frequently become necrotic, producing varying degrees of sloughing of the mucous membrane and at times penetrating the submucous and peritoneal coats producing occasionally a perforative peritonitis.

In less severe types a swelling of the mucous membrane takes place with superficial necrosis and hemorrhage areas and the epithelium of the glandular tubules undergoes a fatty degeneration.

The endogenous variety of gastric toxæmia is far more common than the exogenous form and may have its origin in a great variety of causes. Of special interest are those forms observed in certain affections of the stomach itself, those of intestinal origin and finally, those due to disease of distant organs.

Among the gastric affections in which this condition may be especially noted are dilatation of the stomach, both of the acute and chronic variety, carcinoma and certain forms of chronic gastritis.

Gastric toxæmias are not uncommonly produced by intestinal disease. A very striking instance of this condition is to be found in the vomiting due to intestinal obstruction. It may also occur associated with the intestinal toxæmias, due to constipation or diarrhœa and in such intestinal affections as dysentery, stasis, mucous colitis, and malignant disease.

Gastric toxæmias are also frequently observed associated with disease of distant organs as the kidneys, genito-urinary organs, liver, as well as in diabetes, certain forms of anæmia (pernicious anæmia, chlorosis) and in pregnancy and even in endocrine dysfunction.

(9) DISTURBANCES OF THE NERVOUS SYSTEM

The importance of the nervous system in its relation to the affection of the stomach in old age must always be held in mind.

According to the theory of Eppinger and Hess the symptoms of nervous dyspepsia are due to disturbances of the internal secretions in consequence of which changes in the excitability or tonus are transmitted through the automatic nervous system to the stomach. Based on this theory these authors have evolved a clinical symptom complex termed by them vagotonus and sympatheticotonus. Increased vagotonus produces an increase in gastric secretion (hyperacidity and hypersecretion) and peristalsis (nervous vomiting, cardiospasm, pylorospasm). As forms of increased sympatheticotonus may be mentioned atony of the stomach, achylia gastrica and nervous anacidity.

The following taken from Friedenwald in Osler's "Modern Medicine" presents the incidence of gastric neuroses at various ages.

Years.	Number of cases.	Per cent.
1 to 20	232	14.5
20 to 30	354	22.5
30 to 40	404	25.0
40 to 50	339	21.5
50 to 60	175	11.0
60 to 70	88	5.5

According to our experience 55 per cent. of all gastric disturbances may be classified as neuroses, while but 45 per cent. represent organic disease. In order that a gastric neurosis may exist there must be present some predisposition, that is, neurotic tendency in the individual. This is frequently first manifested by nervous symptoms direc-

ted to other organs, the stomach only becoming involved later. Heredity plays an important rôle. The neuroses rarely have their origin in old age; they begin more frequently in middle life and often continue on as individuals advance to old age.

THE GASTRIC SECRETION AND MOTILITY IN OLD AGE

It has been definitely noted that the general changes that take place as individuals advance in years are similarly accompanied by changes in the gastric secretion and motility. Both Ewald and W. Fenwick have pointed out the occurrence of atrophic changes of the stomach as well as the tendency to the disappearance of free hydrochloric acid as individuals grow older.

Karjuard was the first to systematically investigate this problem. He studied the functions of the stomach in four individuals who were over fifty years of age and who did not complain of any gastric disturbance. He found an absence of free hydrochloric acid and concluded that the hypochlorhydria is related to and proportionate to the degree of arterio-sclerosis.

In further investigation upon seventy individuals of middle life and old age Seidelin observed that free hydrochloric acid was constantly absent in 28 (14 per cent.). In only six (10 per cent.) was there a normal percentage of free hydrochloric acid. Of 45 females 15 (33 per cent.) presented an entire absence of free hydrochloric acid, while in 25 males, 13 (55 per cent.) revealed the same condition. In 48 cases of marked arterio-sclerosis there were 24 with an entire absence of free hydrochloric acid.

Liefschutz examined the gastric contents of 60 individuals of middle life and over; of these 25 showed a constant absence of free hydrochloric acid. He also found achylia gastrica present in 37 per cent. of his cases and concludes that the gastric secretion has a distinct tendency to diminish at this period of life and that an absence of the free hydrochloric acid is not by any means an uncommon condition in old age.

In 1909 Friedenwald reported his observations on 27 cases in elderly individuals, in no instance did any case present symptoms indicating the presence of any gastric disorder. Free hydrochloric acid was constantly absent in 12 of the 27 cases (44 per cent.). In only five was there a normal percentage of free HCl (18 per cent.);

of 19 males eight (42 per cent.) presented an entire absence of free HCl, while of eight females, four (30 per cent.) presented this condition. In eighteen cases of marked arterio-sclerosis there were ten with an entire absence of free HCl, and six with a subnormal amount of free HCl, while in nine cases without arterio-sclerosis there were but two without free HCl. As a further evidence of the fact that the gastric secretion has a tendency to diminish as individuals grow older, Liefschutz draws attention to the fact that 37 per cent. of his cases of achylia gastrica occurred in individuals over the fiftieth year of age. According to our own observations this percentage is 40.

The following table taken from Friedenwald in Osler's "Modern Medicine" indicates the number of cases of achylia gastrica at various ages, amount 112 cases.

Years.	Males.	Females.
up to 20	1	1
20 to 30	5	8
30 to 40	10	9
40 to 50	18	15
50 to 60	15	20
60 to 70	6	4

From our former observations as well as from those of Liefschutz and others, it is evident that the gastric secretion has a tendency to diminish in advancing years and in a degree proportionate to the arterio-sclerosis, and it is therefore unwise to attach too much importance to the absence of this secretion in individuals advanced in years, in the diagnosis of cancer of the stomach.

From more recent investigations of the gastric secretion and motility in individuals of old age our former observations have been confirmed. These examinations were made by means of fractional analyses on 100 patients affected with various gastric disturbances and compared with a similar number of cases in young individuals with identical affections.

Table comparing the acidity and motility in 100 patients in old age with a similar number of young individuals.

Years.	Normal Acidity	Hyper-acidity	Sub-acidity	Anacid-ity	Normal Motility	Hyper-motility	Hypo-motility
	cases	cases	cases	cases	cases	cases	cases
20-40	45	34	12	9	55	29	16
60-80	31	24	19	16	37	14	49

From these observations it is evident that while in youth hyperacidity is more frequent than subacidity, in old age hyperacidity is of less frequent occurrence and subacidity and anacidity are more common.

On the other hand hypermotility is more frequent in youth and atony in old age.

4. The Incidence of Diseases of the Stomach in Old Age, as Revealed by an Analysis of 300 Cases

In order to establish the incidence of the various gastric affections in old age an analysis of the records of 300 cases taken in succession was made and the results tabulated.

	Number of cases.	Per cent.
Acute and chronic gastritis, including achylia gastrica	28	9.3
Ulcer	29	9.6
Cancer	47	15.6
Dilatation	23	7.6
Ptosis	41	13.6
Syphilis	5	1.6
Secondary gastric affections	63	21.0
Nervous gastric affections	41	13.6
Visceral arterio-sclerosis	17	5.6
Unclassified	6	2.0

Arranged according to age and sex, the incidence of the gastric disorders of old age may be classified as follows:—

Diseases	Acute and chronic gastritis		Ulcer		Cancer		Dilatation		Ptosis		Syphilis	
Sex / Ages in Years	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
60 to 65	5	1	9	4	18	10	4	3	4	11	3	1
65 to 70	6	5	7	3	7	4	9	2	6	8	1	0
70 to 75	7	4	4	2	4	4	2	3	2	10	0	0
Total	18	10	20	9	29	18	15	8	12	29	4	1

Diseases	Secondary Gastric Affections		Nervous Gastric Affections		Visceral Arterio-Sclerosis	
Sex / Ages in Years	M.	F.	M.	F.	M.	F.
60 to 65	13	9	6	9	3	4
65 to 70	14	6	3	13	3	1
70 to 75	18	3	3	7	5	1
Total	45	18	12	29	11	6

According to the classification above noted the secondary gastric affections form the largest proportion of the gastric affections of old age, 21 per cent.; next in number is cancer, 15.6 per cent., followed by the nervous gastric affections and ptosis, 13.6 per cent.; chronic gastritis and achylia gastrica, 9.3 per cent.; ulcer, 9.6 per cent.; dilatation, 7.6 per cent., and visceral arterio-sclerosis, 5.6 per cent.

ACUTE AND CHRONIC GASTRITIS

ACHYLIA GASTRICA

In our 300 patients of old age 28 or 9.3 per cent. were affected with gastritis. Arranged according to age and sex, these individuals may be classified as follows:

Ages in years	Male	Female
60 to 65	5	1
65 to 70	6	5
70 to 75	7	4

Of the 28 cases, six presented the acute form while 22 were cases of chronic gastritis and achylia gastrica (atrophic gastritis).

The various forms of acute gastritis differed but little from those observed in younger individuals. It is not infrequent in old age in individuals whose digestion is impaired and proper mastication prevented by the presence of poor dentition. It is not uncommonly observed as the result of overindulgence in food and in alcohol as well as a secondary manifestation in acute infections.

The following table illustrates the 16 cases of chronic gastritis in our series arranged according to age and sex.

Ages in years	Male	Female
60 to 65	3	1
65 to 70	4	2
70 to 75	5	1
Total	12	4

Chronic gastritis occurs in old age as a primary or secondary affection. As a primary disease it occurred in 22 of our 300 cases. We have only embodied in this series however, our cases of achylia gastrica due to chronic atrophic gastritis. The most frequent causes of this affection are errors in diet including the ingestion of coarse and indigestible food, insufficiently masticated as well as the abuse

of alcohol and tobacco. It is not unlikely that neglect in the care of the mouth, infected tonsils and decayed and abscessed teeth or sinus infections are potent factors in the etiology of this affection due to chronic bacterial invasion and intoxication.

In the group of achylias, only those forms are here considered which are due to a chronic atrophic glandular gastritis. Cases accompanied by a complete atrophy of the gastric mucous membrane such as were first described by Fenwick and such as are ordinarily noted in pernicious anæmia are included in this group. There is a senile form of achylia gastrica often occurring in old age in arteriosclerotic individuals in whom a senile atrophy occurs following a chronic atrophic gastritis. Achylias of this character also occur in carcinoma of the stomach and at times cholelithiasis and in pancreatic disease.

The following table illustrates the cases of achylia gastrica in our series arranged according to age and sex.

Ages in years	Male	Female
60 to 65	1	0
65 to 70	1	2
70 to 75	2	0
Total	4	2

ULCER

Ulcer of the stomach and duodenum is not infrequently observed in old age. In the study of our 300 cases of gastric disturbances of elderly individuals there were 29 instances of this disease 9.6 per cent.

Arranged according to age and sex these cases may be classified as follows:

Ages in years	Male	Female
60 to 65	9	4
65 to 70	7	3
70 to 75	4	2
Total	20	9

This table illustrates that ulcer occurs twice as frequently in males as in females in the old age.

In a clinical study of a thousand cases of ulcer of the stomach and duodenum reported by us, this affection occurred in 41 instances between the sixtieth and seventy-fifth years of age, that is in 4

per cent. The following table taken from our study presents the incidence of ulcer in males and females according to age and illustrates the gradual decrease of this affection toward and in advanced life.

Ages	Cases	Males	Females
0 to 10	2	2	0
10 to 20	162	124	38
20 to 30	345	262	83
30 to 40	229	119	110
40 to 50	128	91	37
50 to 60	93	48	45
60 to 70	38	29	9
Over 70	3	1	2

The diagnosis of peptic ulcer in old age is not usually difficult. The usual characteristic pain, hematemesis, melena and the presence of occult blood in the stools and X-ray findings are usually noted in about the same proportion as one observes in younger individuals. There is, however, a tendency to a far lower acidity in the gastric secretion than is noted in the young; subacidity being more common than normal or hyperacidity. The acidities ranged in our cases as follows:

	Number of cases	Per cent.
Normal acidity	8	2.6
Hyperacidity	7	2.3
Subacidity	14	4.6

This observation is in accord with our findings previously noted, that is there is a tendency in old age to a general reduction in gastric acidity.

The greatest difficulty in diagnosis arises often when the onset of the ulceration first manifests itself in old age without any history of previous attacks; with the low acidity of the gastric contents which usually occurs at this period of life, the differential diagnosis between ulcer and cancer may become exceedingly difficult. In most instances, however, a history of previous similar attacks is obtained which usually aids in pointing toward the correct diagnosis.

The treatment of ulcer in elderly individuals differs but little from that in the young, except that these patients should not be underfed for too long a period of time, even when there has been hematemesis. In many of these cases a modified Lenhartz cure is advisable.

The patients are frequently much weakened by the disease as well as by the arterio-sclerotic changes common to this period of life and feeding according to the Lenhartz method may do much to overcome such manifestations early.

For a similar reason, the aged should not be required to remain in bed for too long a time, as the usual protracted rest in bed, as is ordinarily practiced in the ulcer treatment may lead to further weakness or pulmonary complications in these individuals. We have often found it beneficial to allow our patients to remain up, sitting quietly in a comfortable chair at varying times during the day for at least several hours in all, even from the very onset of treatment; these periods being gradually increased as the treatment progresses.

In as much as elderly individuals are not as a rule good operative risks, operation should not be advised except in those instances in which the ulceration shows no tendency to heal under the usual treatment; when complications occur, or in doubtful cases in which the differential diagnosis between ulcer and cancer is impossible.

CANCER

Cancer of the stomach is a common affection of old age though according to our observations, it is more frequently noted in middle life. The following table abstracted from our clinical study of 1000 cases of cancer of the stomach illustrates the number of cases observed in males and females at various ages.

Years	Males	Females	Total
20 to 30	3	1	4
30 to 40	23	14	37
40 to 50	125	136	261
50 to 60	249	146	395
60 to 70	143	75	218
70 to 80	45	40	83
Totals	588	412	1000

Of these cases 303 or 30 per cent. occurred in old age, while 656 or 65 per cent. were noted in middle life.

In a study of our 300 cases of old age, of the 47 cases of cancer of the stomach noted (15.6 per cent.) there were 29 males and 18 females. The incidence of these cases is shown in the following table

which reveals the fact that carcinoma of the stomach is more frequent in males than in females.

Ages in years	Males	Females
60 to 65	18	10
65 to 70	7	4
70 to 75	4	4
Totals	29	18

The disease is more frequent in the white than in the colored race. According to the statistics of our 1000 cases there were 948 whites to 52 colored; that is 94.8 per cent. white to 5.2 per cent. colored.

Of the 52 cases in the colored race 15 occurred in old age (29 per cent.). Of these, 12 were males and 3 females.

In our series the gastric acidities are represented as follows:

	Cases	Percentage
Normal acidity	7	14.9
Hyperchlorhydria	5	10.6
Hypochlorhydria	4	8.5
Anacidity	31	65.9

In as much as there is a general tendency to a diminution in the gastric acidity in old age as has already been pointed out, it is unwise according to our experience to attach too much importance to the absence of this finding alone in individuals advanced in years in the diagnosis of cancer; however, in patients unaffected with this disease neither lactic acid nor the Oppler-Boas bacilli are present which are usually observed in cancer associated with an achylia. A positive Wollf-Junghans test for soluble albumin and a characteristic high blood-sugar tolerance curve are usually noted in this affection, and these together with positive X-ray findings may clear up the diagnosis in obscure cases.

It is most important, too, to remember that in old age, arteriosclerotic changes on account of which there are retrogressive changes and impaired metabolism with loss of strength often present symptoms akin to those seen in cancer, and which may complicate the diagnosis.

Further difficulties often arise by the occurrence of gastric cancer at this period of life in individuals affected with some preceding affection such as diabetes, chronic Bright's disease, cardiac affections

and chronic infections, on account of which there is often marked emaciation, loss of strength, and indigestion; the presence of a carcinoma may on this account therefore be entirely overlooked.

In most instances the symptoms and findings in other respects do not differ in cancer in old age from that observed in younger individuals.

DILATATION OF THE STOMACH

In the study of our cases of dilatation of old age, we have only included those cases in which no motor insufficiency of the second degree was noted; that is where there were evidences of definite retention.

In our series of 300 cases of advanced life, dilatation occurred in 23 instances, that is 7.6 per cent. Of these, six were due to ulcer and seventeen to cancer. The following table illustrates our cases of dilatation due to age and sex.

	Males		Females	
Years	Ulcer	Cancer	Ulcer	Cancer
60 to 65	2	2	1	2
65 to 70	1	8	0	2
70 to 75	1	1	1	2

In all our cases the diagnosis was not only made by the history of retention vomiting as well as the detection of visible peristalsis, but was always confirmed by means of retention meals and X-ray studies.

The differential diagnosis between those cases due to ulcer and those of carcinomatous origin was as a rule not difficult. The long history of ulcer, absence of a palpable tumor, of cachexia, together with the presence of free HCl, and sarcinæ in the gastric contents distinguished the cases from those due to cancer. In addition in every one of our cases due to carcinoma an absence of free HCl, and the presence of lactic acid and the Oppler-Boas baccilli, were noted together with a high soluble albumin content was found in the stomach secretion. In the treatment of dilatation even in old age surgery is usually indicated. In order that the best result may be obtained this procedure should be undertaken early.

Of our 23 cases, operation was performed in 19 instances. Of the six cases due to ulcer, pyloroplasty was done in four instances and gastroenterostomy in two. Of these, four made good recoveries and

two died. Of the 13 cases operated on due to carcinoma, four were found entirely inoperable, and were closed up; of the remaining 9, gastroenterostomies could only be performed. Of these 2 died from the immediate effects of the operation; and the remaining 7 survived for one to eight months in a somewhat improved state for sometime after the operation.

GASTROPTOSIS

Gastroptosis is extremely common in old age and is usually associated with a similar condition of the intestine and frequently of other abdominal organs. It is also often complicated with other abdominal affections at times exerting evident influence upon the symptomatology of such disturbances. We have only included in this series those cases of gastroptosis of old age in which the symptoms manifested were almost entirely due to this affection. Both types of this disturbance are noted at this period of life; the congenital and the acquired form. In the congenital form the prolapse is due to an inherited constitutional weakness, in which the usual clinical manifestations may not be observed, however, until the onset of middle life or old age. In the production of the acquired forms mechanical factors play an important rôle; of these child-birth, trauma, tight lacing, overexertion are especially to be mentioned. Attention must be called to postural defects in their bearing on ptosis. According to the observations of Goldwaite and others, posture is of the greatest importance both as a cause as well as a means in the correction of this affection.

In our study of 300 cases of diseases of old age this affection occurred in 41 instances (13.6 per cent.). The following table presents our cases arranged according to age and sex.

Ages in years	Males	Females
60 to 65	4	11
65 to 70	6	8
70 to 75	2	10
Total	12	29

In many individuals in old age as in younger people affected with this condition no annoying symptoms are observed. On the other hand, in the largest proportion of patients of this group definite manifestations of this affection were noted. The symptomatology in no way, however, differs from that observed in younger individuals.

The gastric secretion presents a variable degree of acidities though subacidity is more frequent.

In our 41 cases the acidities were noted as follows:

Normal acidity in 12

Hyperacidity in 9

Subacidity and anacidity 20

SYPHILIS

Gastric syphilis is a rather rare affection though it appears most frequently in middle life and old age. According to Mills one case occurs in every 100 cases of organic gastric lesions of all forms and in 300 cases of the gastric disturbances of old age it appears in five instances (1.6 per cent.). It occurs much more frequently in males than in females. The following table presents our cases arranged according to age and sex.

Ages in years	Males	Females
60 to 65	3	1
65 to 70	1	0
70 to 75	0	0
Total	4	1

In the largest proportion of instances, these cases have occurred in the tertiary stage of the disease, though secondary syphilis is frequently accompanied by symptoms of indigestion due as a rule to a toxæmic gastritis.

This affection occurs most commonly in the tertiary stage of syphilis, ulceration being the most frequent. The latter results either from the degeneration of a gumma or from the destruction of a localized area of the stomach produced by an endarteritis. The symptoms observed are similar to those of gastric ulcer, though relief is not afforded by food and alkalies, hemorrhages are rare, the appetite remains good, the gastric secretion usually presents a true achylia, the X-ray strongly suggests carcinoma and, although there is marked loss of flesh, there is no proportionate cachexia. Tumor formation and pyloric stenosis are not common but these conditions have occasionally been observed. The Wassermann reaction is usually positive and in doubtful cases a provocative test is indicated.

According to Eusterman, "A gummatous ulcer, usually multiple, and especially a diffuse syphilitic infiltration with variable degree

of contracture, thickening, deformity and perigastric adhesions chiefly involving the pyloric segment, is the usual pathologic condition."

According to Mills the salient X-ray features are: "First that of a general but locally accentuated contour defect; second, a general diminution in area of the gastric shadow; third, that of motor impairment of either the obstructive or more usually the residual type and fourth, though less important, atypical peristalsis."

SECONDARY GASTRIC AFFECTIONS

Attention has already been directed to the very frequent occurrence of the disturbance of the functions of the stomach in diseases of other organs. In youth such affections are rather unusual, but as individuals advance in years the incidence gradually increases so that in old age they comprise the largest proportion of gastric disturbances of that period. In the study of our 300 cases of the gastric disturbances of old age the secondary disturbances number 63 cases (21 per cent.) occurring more frequently in males than females.

The following table presents our cases arranged according to age and sex.

Age in years	Males	Females
60 to 65	13	9
65 to 70	14	6
70 to 75	18	3
Total	45	18

The cause of these secondary gastric affections lies as we have already pointed out, either in some disturbance of the circulation, nervous system or is due to a toxæmia. The diseases in which disturbances of the gastric function are particularly noted during old age are tabulated as follows in our 63 cases.

	Number
1. Acute febrile diseases	2
2. Disease of the intestine	6
3. Diseases of the liver and gall-bladder	10
4. Diseases of the pancreas	2
5. Diseases of the kidneys	14
6. Diseases of the heart and blood system	16
7. Diseases of the lungs	7
8. Diseases of metabolism	2
9. Diseases of the nervous system	4

(1.) *Functions of the Stomach in Acute Febrile Diseases.*—The gastric disturbances in acute febrile diseases such as in typhoid and pneumonia are accompanied by a diminution and in some instances with an absence of free HCl; there is also a weakened motor-function at hand. During convalescence an increase in secretion is noted.

(2.) *Functions of the Stomach in Diseases of the Intestines.*—These affections comprise largely, chronic constipation, ileocolitis, diverticulitis, intestinal obstruction, chronic appendicitis and peritonitis. There were six cases due to these conditions in our series.

(3.) *Functions of the Stomach in Diseases of the Liver and Gall-Bladder.*—There were 10 cases of these affections in our series. Of these, three were due to liver disturbances and to gall-bladder affections. The stomach is not infrequently affected secondarily as the result of diseases of the liver and gall-bladder. Obstruction of the circulation due to disturbances of the liver occasions congestion of the stomach and may lead to a gradual reduction in acidity, while enlargement of the liver may displace the stomach, causing mechanically interference with its motility; again any inflammation of the liver or gall-bladder may result in adhesions to the stomach with consequent interference with the gastric functions. Atrophic cirrhosis of the liver is almost always associated with a chronic gastritis often of the interstitial or glandular type, which is followed by venous congestion due to portal obstruction and hemorrhage may ensue from rupture of the varicose veins surrounding the cardia.

In cholecystitis and cholelithiasis the gastric symptoms may be so prominent as to render the diagnosis difficult; these may consist of pain, nausea, vomiting, and the pain may be localized in the epigastrium instead of over the gall-bladder region which in these elderly individuals tends to force one at times to the erroneous diagnosis of carcinoma. In gall-stone disease, pylorospasm is frequent and the production of adhesions between the gall-bladder and pylorus often leads to interference with motility. In the early stages of gall-bladder disturbances hyperacidity is usually present (60 per cent.), anacidity in 18 per cent. and normal acidity in 22 per cent., but as the disease advances to old age, anacidity has been our usual finding.

(4.) *Functions of the Stomach in Diseases of the Pancreas.*—Acute pancreatitis is usually associated with gastric symptoms in

the form of severe nausea, vomiting, intense pain, located about the umbilicus, while in the chronic forms and in carcinoma of the pancreas there is nausea, vomiting, eructation and distress following the ingestion of food. In our series there were two cases of cancer of the pancreas producing gastric symptoms.

(5.) *Functions of the Stomach in Diseases of the Kidneys.*—Nephritic affections are usually accompanied with symptoms referable to the stomach. These are largely due to the toxæmia produced by the renal lesion caused by the excretion of urea and other poisons through the gastric mucosa as well as to the cerebral irritation from the poison. When the lesion is extensive or of long duration marked changes may take place in the gastric mucous membrane; first, in the form of acute inflammation of the gastric tubules with swelling, irregularity and granular degeneration and in the latter stages, as a chronic inflammation of the glandular structures, the peptic cells undergoing fatty infiltration and finally as an inflammatory thickening of the interglandular tissue. In rare instances hemorrhage takes place in the mucous membrane of the stomach and superficial ulcers of variable sizes may be formed.

The character of the gastric secretion varies according to different observers; according to Biernaki the free HCl is diminished in proportion to the secretion of albumin, reduction in quantity of urine excreted and extent of the œdema. Free HCl is usually observed in the early stages but in extensive chronic lesions of the kidneys, achylia gastrica is usually noted. The pepsin and rennet ferments are always diminished and are frequently entirely absent; the motor function is usually increased.

In the early stages of chronic nephritis the gastric symptoms are often so prominent that unless careful urinary examinations be made erroneous conclusions may be arrived at. The gastric symptoms accompanying nephritis are nausea, vomiting, discomfort after meals, loss of appetite and flatulency. The vomiting of renal disease often occurs immediately on arising in the morning and is associated with much retching, the vomitus consisting of mucous mixed with yellow bile and saliva. When vomiting occurs later, it may appear immediately or an hour or two after meals, and the ejected matter, may contain undigested food with mucus. In uremia the vomiting takes place at frequent intervals and especially upon any attempt at nourishment; the vomited matter consisting of mucus, which is bile tinged.

In obstruction to the passage of urine due to prostatic disease, the symptoms associated with gastric digestion in the form of loss of appetite, nausea, vomiting, distention, loss of flesh, are frequently so prominent that the question of carcinoma of the stomach cannot always be ruled out.

(6.) *Functions of the Stomach in Diseases of the Heart and Blood System.*—In heart affections in which compensation is present the gastric functions are usually normal, but when compensation is interfered with, the portal system becomes congested, in consequence of which, stasis and hyperemia of the gastric mucosa is produced. After long continued congestion of the stomach due to heart disease the mucous membrane becomes filled with hemorrhages; there is intense congestion of all the veins and capillaries, the gastric tubules becoming irregular or compressed and the cerebral and parietal cells swollen. The gastric secretion in the early stages of this affection is usually normal, but gradually diminishes in its acid content; the pepsin and rennet ferments decrease and in advanced cases gastric motility is much impaired.

The gastric symptoms noted in cardiac disease are distention, pressure, fullness and palpitation after meals; anorexia is marked and nausea and vomiting ensue.

The vomiting consists of bile-stained mucus often containing traces of blood; rarely hematemesis may occur. On palpation of the abdomen, the region of the stomach is found markedly distended and tender on pressure.

In pernicious anæmia, anorexia, nausea and vomiting frequently occur and the gastric secretion ordinarily presents a complete achylia.

In chronic and secondary anæmia, gastralgia, anorexia and hyperchlorhydria are usually noted.

(7.) *Functions of the Stomach in Diseases of the Lungs.*—The disease of the lungs which sooner or later gives rise to gastric symptoms is tuberculosis. The various changes observed in the stomach in this affection are atonic dilatation, ulceration, and the various forms of gastritis. The gastric disturbances of pulmonary tuberculosis ordinarily noted may be divided into two groups; first, the dyspepsia observed in the initial stages of the disease and second, that of the final stage.

(1) The Initial Dyspepsia.

In the initial stage of the disease gastric symptoms are manifested according to Samuel Fenwick in 83 per cent. of cases and according to Saltau Fenwick in 79 per cent.; being more common in females than males. The symptoms appear very insidiously frequently even before the pulmonary signs have become sufficiently marked to be noted by the patient. These consist of pain or discomfort following immediately upon meals or several hours afterward; vomiting especially appearing early in the morning preceded by cough or irritation in the throat, the vomited matter consisting of mucus from the pharynx, bronchi and stomach; loss of appetite; flatulency, and acidity. In this stage, the gastric secretion is normal or hyperacidity may exist, the motor function being normal or slightly reduced.

(2) Terminal Dyspepsia.

In the terminal stage of this affection the dyspeptic symptoms are extremely marked. Of 316 cases of advanced tuberculosis, Fenwick observed that 42 per cent. were affected with dyspepsia. This condition is more common in females than males; 62 per cent. of females to 25 per cent. males.

The symptoms manifested at this stage are anorexia, flatulency or discomfort in the epigastrium usually unaffected by the ingestion of food; nausea and vomiting frequently induced by coughing. The gastric secretion gradually presents a lessened acidity, and in advanced cases there is usually a true achylia; the motility of the stomach being also reduced.

(8) *Functions of the Stomach in Diseases of Metabolism. Diabetes.*—The digestion of diabetes is often normal. On the other hand, patients affected with this disease are liable to indigestion, chronic gastritis and atrophy of the gastric mucosa have been noted in a few instances. The gastric symptoms manifested are bulimia, polyphagia, abdominal discomfort, distention and eructations. Occasionally when an attack of gastritis arises, pain in the epigastrium is induced followed by nausea and vomiting. Violent pain may ensue preceding the development of coma.

The gastric secretion in this disorder is variable and normal hyperacid and achylic states may be observed. The gastric motility may be normal or hypermotility may be present.

(9.) *Functions of the Stomach in Diseases of the Nervous System.*—Organic diseases of the brain or spinal cord are usually accompanied with gastric symptoms. In tumors of the brain, in cerebral abscess or hemorrhage, vomiting is a prominent symptom; it is usually projectile in character and preceded by headache and is in no way related to the ingestion of food; the vomitus consisting largely of hyperacid gastric secretion containing bile.

Locomotor ataxia produces gastric symptoms in the form of abdominal crises. These crises are manifested by sudden attacks of acute pain in the epigastrium, radiating into the abdomen, back and limbs. The pain is of the girdle type and vomiting frequently occurs at the onset of the pain. The vomitus consists of the contents of the stomach and then of mucus tinged with bile. Hypersecretion is usually present during the attack.

NERVOUS GASTRIC AFFECTIONS

We have already pointed to the great importance of the nervous system in its relation to affections of the stomach in old age and to the frequency of these disturbances. The gastric nervous disorders rarely take their onset in old age; they occur more frequently in youth and middle life; while 46 per cent. is noted as the incidence between the thirtieth and fiftieth years, 16 per cent. is observed between the fiftieth and seventieth years according to Friedenwald (Osler's "Modern Medicine").

Of our 300 cases of gastric disorders of old age, there were 41 cases of nervous affections (13.6 per cent.). The following table presents our cases arranged according to age and sex.

Age in years	Males	Females
60 to 65	6	9
65 to 70	3	13
70 to 75	3	7
Total	12	29

The symptoms of the gastric neuroses in old age is not unlike those observed in younger individuals. The symptoms of a general neurosis are usually present, that is, irritability, lassitude, insomnia and depression. The subjective symptoms are changeable and capricious, exhibiting protean changes in rapid succession.

The digestive complaint is frequently independent of the quantity

and quality of food ingested and frequently bears no relation whatever to meals. Frequent and sudden changes take place in the secretory and motor functions of the stomach or in both, so that a superacidity may quickly give way to a subacidity and a motor insufficiency to a hypermotility.

The diagnosis may often be difficult as similar symptoms may envelope organic affections in old age, the nervous manifestations being so much more prominent that the actual disease becomes entirely masked.

In order to establish the nervous character of the gastric disorder, organic disease must be excluded, which is by no means always an easy task. A further difficulty arises from the fact that organic disorders are often accompanied by nervous symptoms and most careful investigation is therefore always necessary.

While any of the various gastric neuroses may occur in old age only a few are important.

Cardiospasm occurs at times, secondary often to gall-bladder disease. It is important to differentiate this affection from cancer at the cardia. Similarly pylorospasm due frequently to chronic appendicitis must be distinguished at times from cancer at the pylorus.

Pneumatoses which is characterized by an excessive distention of the stomach occurs not infrequently in old age. The region of the stomach is much distended and the patient is unable to relieve himself by eructation.

Aerophagia is not uncommonly observed in patients of advanced years and occurs in neurasthenic and hysterical individuals. Bulimia characterized by an abnormal increase in the sensation of hunger is also frequently noted at this period of life while atony of the stomach and nervous anorexia are not unusual manifestations.

VISCERAL ARTERIO-SCLEROSIS

Visceral arterio-sclerosis occurring during old age as associated with the digestive tract and especially the stomach has hitherto according to our experience not been accorded sufficient attention. This condition occurs much more frequently than is usually acknowledged.

Of our 300 cases of gastric disorders of old age, arterio-sclerosis appeared in 17 instances, 5.6 per cent. It occurred almost twice as

frequently in males as in females. The incidence according to age is as follows:

Ages in years	Males	Females
60 to 65	3	4
65 to 70	3	1
70 to 75	5	1
Total	11	6

As individuals advance in years and arterio-sclerosis changes slowly make their appearance, disorders of digestion become more common and indigestion can then only be avoided by care in diet.

Samuel Fenwick has noted that 21 per cent. of all elderly individuals suffer more or less from chronic indigestion due largely to this cause.

As has been previously noted arterio-sclerosis leading to gastric disturbances may be observed as one of two distinct types.

(1) Those instances in which the arterio-sclerosis changes are primarily in the stomach itself, and

(2) Those in which the manifestations are secondary to a general arterio-sclerosis.

As an etiological factor concerned in the production of this condition is the natural wear and tear of life as manifested in the changes in the blood vessels with advancing years. In many instances these changes are only noted at the onset of old age; while in others they appear early, already being fully developed in middle life. There can be but little question, that the early onset of this affection is frequently due to such factors as overwork, mental overstrain, overindulgence in food, and drink, syphilis, other infectious diseases; and toxic factors such as gout, lead poisoning, alcohol and intestinal toxæmias. Heredity plays an important rôle often, as one frequently observes early arterio-sclerosis in members of the same family.

The pathological change is degenerative in character affecting both the arteries and also the walls of the stomach. The arteries may be partly or almost wholly occluded due to the increase in connective tissue in the intermediate layer as well as to the proliferation of the endothelium. The new connective tissue formation may form diffusely or in circumscribed areas in the larger vessels, the endothelium often proliferating or undergoing fatty degeneration. Cystic degen-

eration often takes place in the newly developed connective tissue producing the well known "atheromatous cysts," these extending into the vessels' lumen may produce emboli or ulcerations with thrombotic formation. Calcification may take place in the newly formed fibrous tissues of the intima and atrophy and calcification in the muscularis and adventitia.

The main clinical gastric manifestations recognized in old age as the result of general arterio-sclerosis and of arterio-sclerosis of the abdominal arteries may be divided into three groups.

(1.) The dyspepsia due to general arterio-sclerosis.
(2.) Abdominal angina.
(3.) Gastric ulcer with or without hemorrhage.

(1.) *The Dyspepsia Due to General Arterio-sclerosis.*—These symptoms usually begin insidiously and are principally manifested in the form of flatulency, fullness, distension, nausea, eructations, dizziness, palpitation and shortness of breath.

At first but a few of these symptoms are noted, and then only on awakening in the morning and are often relieved by eructations of gas. The appetite for breakfast gradually diminishes and the patient finally is unable to eat until the noon meal. While the noon meal may be taken with relish, the symptoms above noted are apt to return in the afternoon and epigastric distress is not uncommon. As time goes on the general abdominal distention, distress and eructations are constantly at hand. Nausea and retching after meals are not infrequent, but vomiting is rarely noted. Tachycardia, dyspnœa, tightness of the chest are not uncommon adding further to the distress of the patient. The flatulency at times increases in severity especially at night and the patient is forced to sit up in bed in great discomfort making efforts to eructate and often suffering with marked dyspnœa.

The night attacks are frequently increased by the evening meal and on this account the patient frequently places himself upon a liquid or semi-solid diet.

The symptoms just noted may exist with varying degrees of intensity for years and may even disappear for a short period of time to return often with great severity. At this period, however, the dyspnœa, flatulency and epigastric distress appear even on slight exertion even without relation to food. Intestinal flatulency and distress now manifest themselves and the patient loses weight and

strength, the symptoms progress and the patient may die either from an intercurrent cerebral, cardiac or renal complication or from exhaustion.

(2.) *Abdominal Angina.*—Abdominal angina occurs frequently as the result of an abdominal endarteritis. These changes of an inflammatory and degenerative character take their onset slowly in the abdominal aorta and its branches and are progressive and are the cause of ill-defined, though often severe, abdominal pain. This pain is usually paroxysmal in character, is often increased on exercise, is relieved by rest and is associated with tenderness on pressure along the aortic plexus and with lancinating pains extending along the course of the iliac and femoral vessels.

Harlow Brooks has called attention to the fact that the disturbed visceral function often associated with pain and elevation of blood pressure which cannot otherwise be accounted for, is frequently the cause of some localized area of abdominal arterial disease.

The pain caused by arterio-sclerotic changes in the abdominal aorta may be observed in the epigastrium, thorax or lower abdomen. Like angina pectoris, it is ordinarily increased on exertion or excitement, and is accompanied with tachycardia and hypertension. The pain is often transmitted into the dorsal and lumbar regions of the spine and disappears under the influence of rest and the administration of the nitrites. According to Allen Jones "it may be termed abdominal claudification and is accompanied by a consciousness of heavy hammering intra-abdominal pulsation, which rivets the patient's attention, is somewhat alarming and prompts him to seek immediate physical and mental relaxation."

When the gastric branch is involved in this condition, epigastric pain often of a very severe type is induced by a full meal which is not entirely relieved until the stomach has entirely emptied itself; light meals produce but moderate discomfort.

(3.) *Gastric Ulcer, With or Without Hemorrhage.*—The character of the formation of these ulcerations has already been described. They are definitely due to degenerative changes as a result of marked ischemia of certain parts of the gastric wall caused by an arteriosclerosis (often a thrombo-angeitis of a branch of the gastric artery). A frequent cause of the hemorrhages is found in the rupture of the miliary aneurysms in the small gastric arterioles.

When in individuals in advanced years with evident manifestations of arterio-sclerosis, the usual signs of ulcerations occur, one should always suspect the presence of this affection. On the other hand in as much as carcinoma may have its onset in a similar manner, the diagnosis may become even more complicated.

When hemorrhage occurs with this form of ulceration the diagnosis becomes much less difficult, though as has already been noted hemorrhages do occur even of a massive type as a result of the rupture of the arterio-sclerotic vessels in the stomach. Cases of this character have been reported by Simon and similar observations have been noted by us.

In order to arrive at a correct diagnosis of this affection, a thorough physical examination of the patient should be made and not too much reliance should be placed upon the mere symptoms of indigestion.

In a patient of advanced years complaining of flatulency, distention and with epigastric pains and dypsnœa which are relieved by eructations, especially when these symptoms are aggravated at night, a careful examination into the cardiovascular system should be made. Not infrequently there will be revealed marked hypertension, with an enlarged heart, with an eccentuated second aortic sound or a murmur over the aorta, pulsation in the episternal notch, discomfort on pressure along the abdominal aorta together with an increase in the urine which is of low specific gravity and contains albumin and casts. These findings point directly to the arterio-sclerotic changes as causative factors in the production of the gastric affection.

CONCLUSIONS

From our study of the 300 cases of the various gastric affections of old age it becomes evident (1) that these affections differ in many respects from those occurring in younger individuals; (2) that these variations are largely the result of infectious processes, degenerative changes and arterio-sclerosis and are manifested frequently in changes in gastric secretion and motility together with other more or less characteristic symptoms; (3) that in the study of the gastric disorders of old age these variations should be clearly borne in mind in drawing conclusions concerning this diagnosis and treatment of these affections.

Surgery

SOME NEWER ASPECTS OF CHEST SURGERY

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Recent military experience has taught us that surgery of the lungs can be brought under the same general principles as govern other organs of the body. We have learned that the chest cavity may be widely opened and explored just as the peritoneal cavity; that it is unnecessary to resort to special appliances for the maintenance of negative pressure; that one need not fear pneumothorax even in the presence of large openings, and that it is possible to grasp the different lobes of the lung with suitable forceps and bring them into the wound for examination and the performance of necessary surgical procedures. It must not be inferred, however, from these statements that lung surgery is easy or that it should be undertaken by any but skilled surgeons.

In the French Army the technic of chest surgery was developed to a high degree, and the mortality of chest wounds was reduced from 45 per cent. under the expectant treatment to 10 per cent. under operative treatment. The dictum which prevailed in peace times—"that bullets in the tissues were harmless and should be left alone"—dominated the minds of army surgeons in the early part of the war, and even after the great value of *"débridement,"* or wound cleansing, was recognized, wounds of the chest and lungs were still treated expectantly. Failure to employ the same methods in chest wounds as those used in other parts of the body cost the lives of thousands of young men. Wounds of the chest and lungs were the last to be brought under the same principles as governed the treatment of all war wounds.

Infection and suppuration occurred in almost all wounds produced by high explosives and it was soon learned that early removal of dead and infected tissues, together with the infecting foreign body, would prevent the deeper penetration of infection and quickly restore the tissues to normal. These methods were found applicable to

wounds of the lung. Operations on the chest were undertaken in the front-line hospitals under the following conditions:

(1.) When there was extensive hemorrhage threatening life.

(2.) When there were sucking wounds threatening asphyxia.

(3.) When there were large foreign bodies in the lung likely to cause infection.

In all cases requiring immediate operation the thorax was widely opened by means of resecting a rib and then using a rib spreader. In case of severe hemorrhage the different lobes of the lung were seized with forceps of the sponge-holding variety and drawn into view when the bleeding vessel could be ligated or a lobe resected, and sutured. There was a high mortality in these cases, from 40 to 50 per cent., but under the no-interference method almost all of them died.

Lung wounds containing fragments of bone, pieces of shell and clothing were treated by removal of the foreign body through the widely opened chest. Wounds of the diaphragm were sutured through the thoracic wound and the track of foreign bodies followed into the liver or viscera of the upper abdomen. Most of these desperate cases, if treated expectantly, died, but if operated upon in the manner indicated above—within twelve hours—50 to 60 per cent. of them recovered. This type of wound constituted the most heart-rending and appalling with which the army surgeon had to deal. The picture presented by these wounded men will never be forgotten by those who served in front-line hospitals. Cyanotic, with short, jerky respirations, sucking air in and out through the wound with each respiration, suffering intense pain, with rapid, weak pulse and with a look of desperation upon their faces, they seemed doomed. To operate seemed foolhardy; to wait meant certain death. Little wonder that these patients were abandoned to their fate in the early years of the war. Most of them died in advanced dressing stations, field hospitals or in ambulances while being transported to the rear. A startling transformation took place when provision was made in the last two years of the war for the early surgical care of these wounds. Sucking wounds threatening asphyxia were treated by excising the infected wound edges and tightly closing the skin over the chest wall. It was most essential that all chest wounds be closed tightly, preventing the ingress of air.

It was necessary to aspirate many of these cases repeatedly for hemothorax. In a large percentage of them, after three or four aspirations, the pleural cavity would clear up and no drainage was required. In a small percentage of patients empyema would develop, requiring drainage.

The author's personal experience consisted of 46 gun-shot wounds of the chest, 33 of which were pentrating wounds involving the lungs and pleural cavity. The points of special interest in chest surgery brought out by our experience in the war are:

(*a*) That non-penetrating wounds of the chest often cause serious intra-thoracic injury, *e.g.,* hemothorax, infarction of the lung, etc.,

(*b*) The lung has great resistance to infection. Lung infection was comparatively rare.

(*c*) In severe chest injuries, lung collapse was almost invariable.

(*d*) Pneumothorax associated with a sucking wound of the chest is a most dangerous condition and the relief afforded by closure of the wound is instantaneous and startling.

(*e*) Local anæsthesia and gas-oxygen anæsthesia are the best methods of lessening shock in chest operations.

Emphasis has been laid upon the teachings of the war relative to chest wounds, inasmuch as the same timidity which at first restrained army surgeons from giving wounded men the full benefits of surgery has also prevailed in civil practice.

Tradition has greatly retarded the progress of scientific medicine. In no field of medicine is this so strikingly illustrated as in that of thoracic surgery. The earliest annals of history record injuries of the chest and even in the time of Hippocrates drainage was practiced for empyema, and yet no substantial progress was made in this field until recent years.

The chest, the most exposed and at the same time the most vital part of the body, has been the target of every weapon that man has devised for the destruction of his enemies. The recent war was no exception to this rule, for the most formidable weapons evolved out of the World War were the poisonous gases designed to asphyxiate men.

The greatest obstacle to surgery of the chest has been the fear of acute pneumothorax. Wounds of the chest have always been considered very serious and fear of pulmonary collapse has deterred surgeons from attacking these injuries with the same confidence that

pertains to other parts of the body. When the pleural cavity is opened accidentally, as by a stab wound, or purposely, as by incision, in the absence of adhesions there is an immediate collapse of the lung due to the fact that the atmospheric pressure is greater than that within the pleural cavity. Complete collapse, however, rarely occurs. Large openings seem to cause no greater collapse than puncture wounds. Not only does the lung on the injured side collapse to some degree, but the mediastinum is also pushed to the opposite side and the lung on the other side is compressed. The excursion of the mediastinum is so limited that when pushed to the opposite side with the heart and the large vessels, it seriously interferes with the expansion of the lung on the healthy side.

The restricted respiratory movement is insufficient to carry on the necessary exchange of gases; carbon dioxide rapidly develops in the blood; this in turn depresses the respiratory and circulatory centres; dyspnœa and finally asphyxia with death supervene.

Efforts to place surgery of the chest upon a sound basis have been directed largely toward overcoming this disparity between atmospheric and thoracic pressure. Nature accomplishes this for us in such inflammatory affections as empyema by forming firm adhesions between the lung pleura and the parietal. It is due to this fact that for centuries surgeons have practiced rib resection and drainage for inflammatory affections of the lung and pleura.

It is only since 1904 that artificial means to overcome lung collapse have come into vogue, but they have proven so cumbersome, uncertain and difficult of technic that they have contributed little to the progress of thoracic surgery. The discovery of anæsthesia and asepsis resulted in startling developments in almost every field of surgery except that of the chest. It required the impetus of the World War to awaken a new interest in this field and even then it lagged far behind the surgery of other parts of the body.

The factors which have contributed most to the development of this new field of surgery are:

(1.) Studies in the vital capacity of the lungs.
(2.) Routine X-ray examinations.
(3.) Bacteriological studies.
(4.) Improved technic and special instruments.
(5.) The Carrel-Dakin treatment.

The studies of Graham and others in vital lung capacity bear a very important relation to thoracic surgery. While they have contributed little of practical value to the technic, they have furnished an explanation for the high mortality in certain types of cases and may yet afford a means of selecting more accurately cases suitable for operation. The vital capacity represents the greatest possible volume of air that one can voluntarily take into his lungs in addition to the already present residual air. It is possible to measure with considerable accuracy the vital capacity in any individual. The average in men is about 4800 c.c., while that of women is only 3500 c.c. The vital capacity of the lungs is extremely low in empyema, especially in the streptococcus type of infection where there are few limiting adhesions, and the high mortality in this type of cases following early operation was due in large measure to this low capacity.

Even after the aspiration of large quantities of purulent fluid, the lung only gradually recovers its normal capacity. The common belief that the mediastinum forms a rigid partition and that a pneumothorax can exist on one side without affecting the other, Graham and others have shown to be entirely false. The opposite side suffers almost equally with the one containing the pneumothorax and for all practical purposes the thoracic cavity may be considered as one chamber, except in the presence of adhesions or a rigid mediastinum. Notwithstanding these facts, recent experience has taught us that we need not fear pneumothorax and that it is quite safe to open the chest and perform any indicated operation upon the lungs.

The value of routine X-ray examinations in lung conditions cannot be too strongly emphasized. Full-sized stereoscopic plates should be taken in every doubtful case. Almost every lesion affecting the pleural cavity and its viscera can be illuminated by careful röntgenographic study. The presence of pneumothorax, the existence of limiting adhesions, the level of fluids in the chest, localized collections of pus, tuberculous cavities, primary and metastic growths, syphilis, the size and contour of masses making pressure from without, foreign bodies and the size and position of the heart, are all revealed by this method of examination. The study of sinuses and old empyema cavities, outlined by bismuth paste, is a valuable guide to surgical treatment.

The contributions of bacteriology to chest surgery are little less significant than those of röntgenology. Bacteriologic control combined with frequent radiographic examinations lends an accuracy to chest surgery comparable to that afforded in genito-urinary surgery by the cystoscope and functional tests of the kidney.

Improvements in technic and methods of anæsthesia have greatly increased the safety and enlarged the field of thoracic surgery. By means of an intercostal incision and a powerful rib spreader, all parts of the chest cavity and its contents may be exposed. The only other special instruments required are forceps of the sponge-holding type to grasp the lungs, and suitable retractors.

Anæsthesia is a most important factor in successful chest surgery. Local anæsthesia is the method of choice. Nitrous oxide and oxygen may be a necessary adjunct in nervous patients and during painful manipulations. A preliminary hypodermic of morphine and scopolomine or atropine is essential. Infiltration of the skin along the line of incision with one per cent. novocaine and blocking of the intercostal nerves at the intervertebral foraminæ afford adequate anæsthesia for extensive operations. Chloroform and ether are strongly contraindicated. (See Figs. 1 to 5, illustrating technic.)

The Carrel-Dakin treatment has proven of the greatest value in treating infected chest wounds and sinuses. Only those who are unfamiliar with its use or blinded by prejudice can fail to recognize this fact. The closed method of treating empyema with Dakin's solution, as advocated by Mozingo and approved by the Surgeon General, will doubtless become the routine method of the future.

The vast majority of patients demanding surgical operations upon the chest fall into three classes:

I. Empyema.

II. Lung abscess.

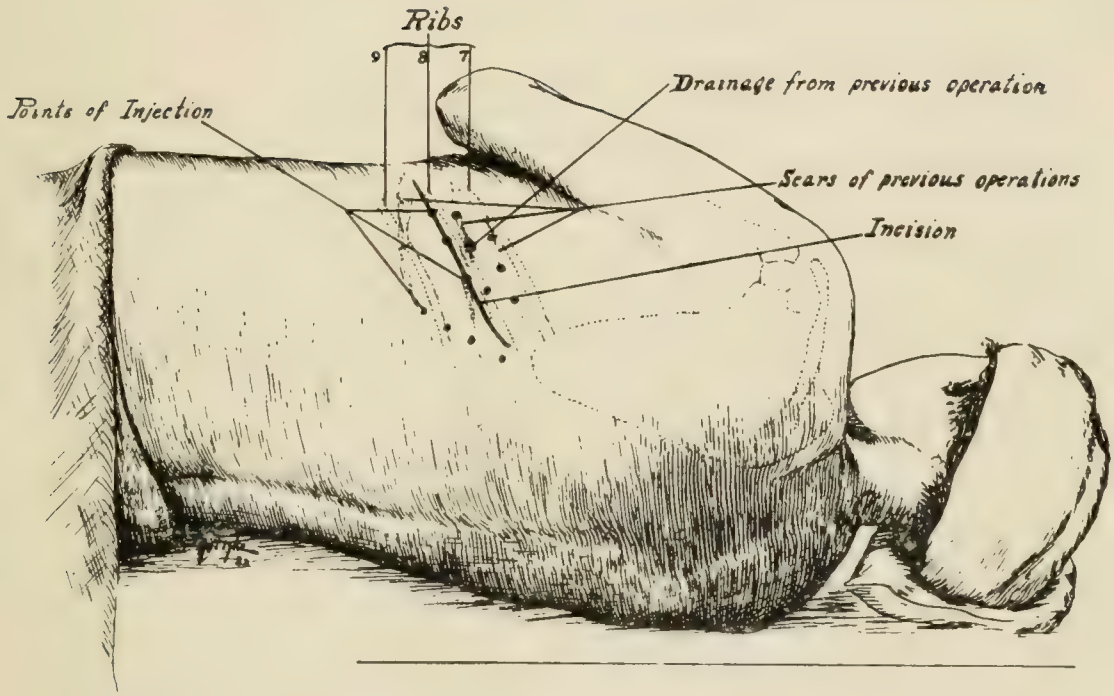
III. Advanced tuberculosis.

I. *Empyema.*—Notwithstanding the vast amount of experience gathered during the war and the great number of papers written since the war on this subject, these cases are still badly treated by the average surgeon. The common mistakes made are:

(*a*) Poorly placed drainage tubes.

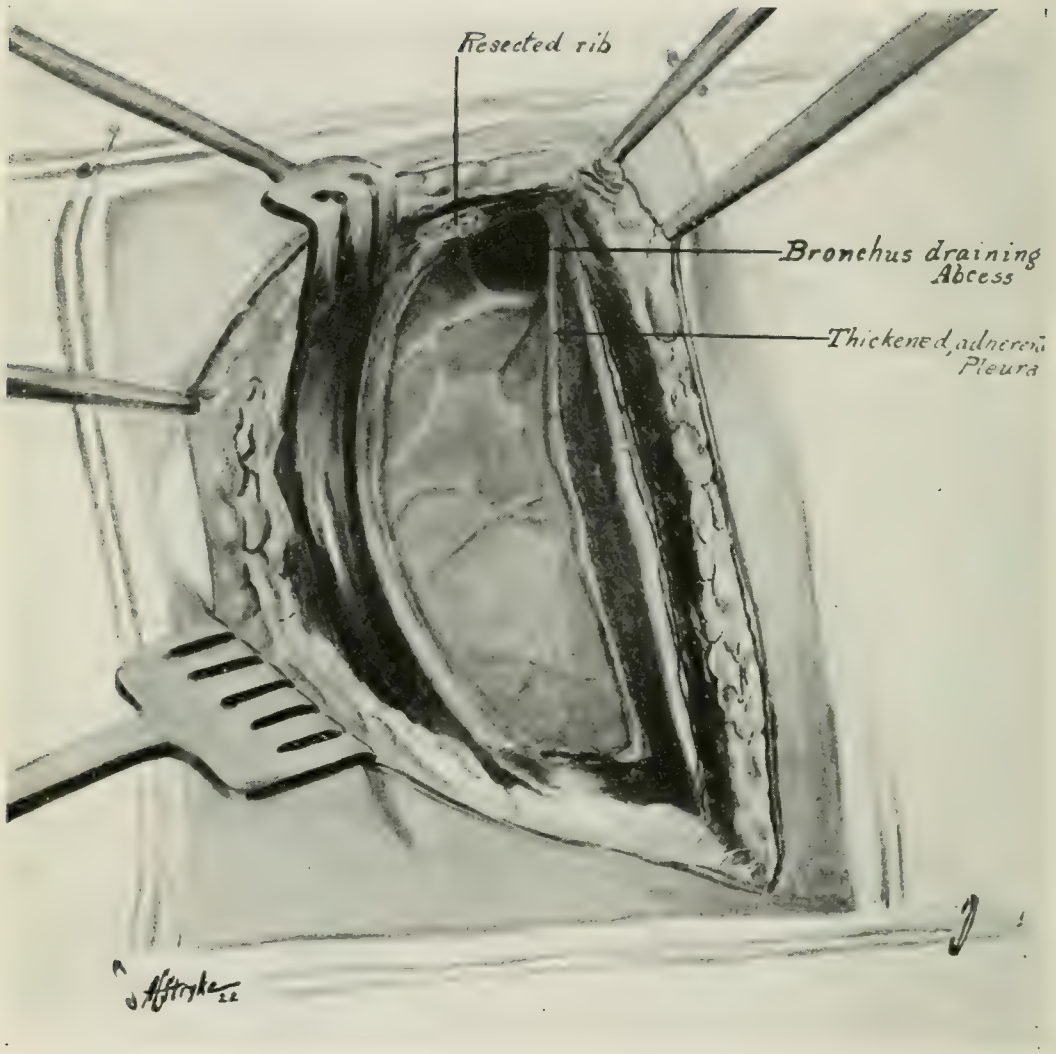
(*b*) Drainage tubes of too great length and rigidity, causing

FIG. 1.



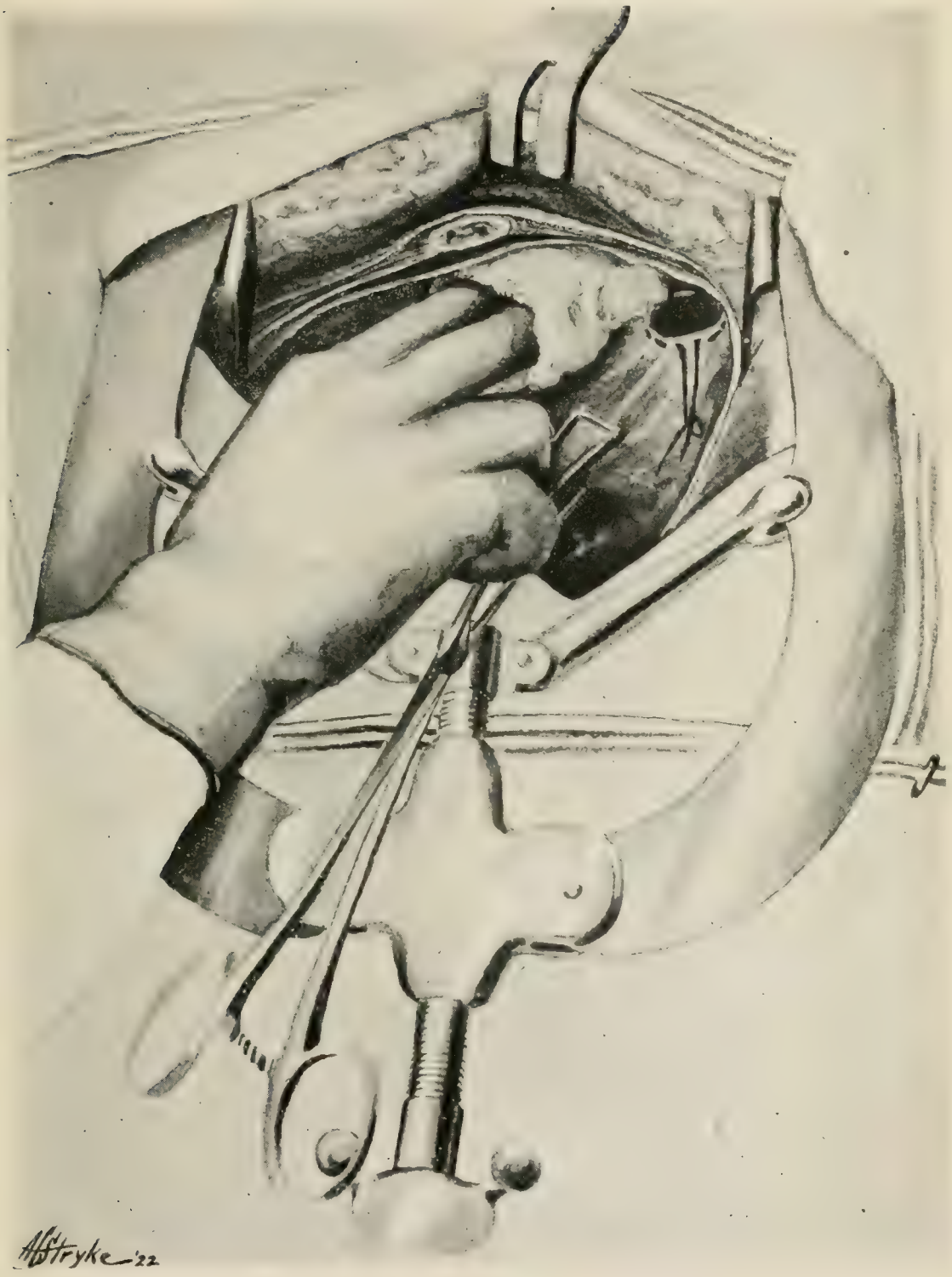
Semi-diagrammatic illustration of technic in chest surgery as followed in Case III. Position on table.

Fig. 2.



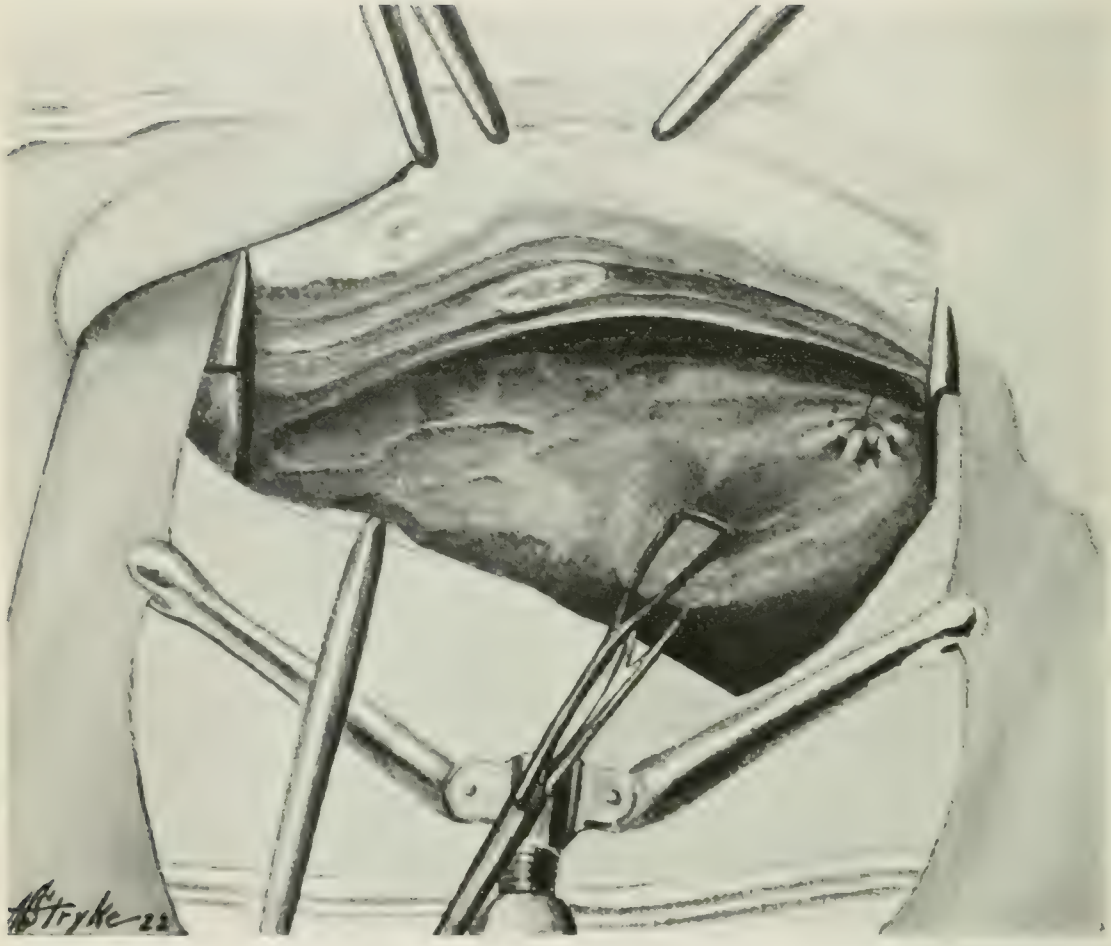
Semi-diagrammatic illustration of technic in chest surgery as followed in Case III. Exposed operative field.

FIG. 3.



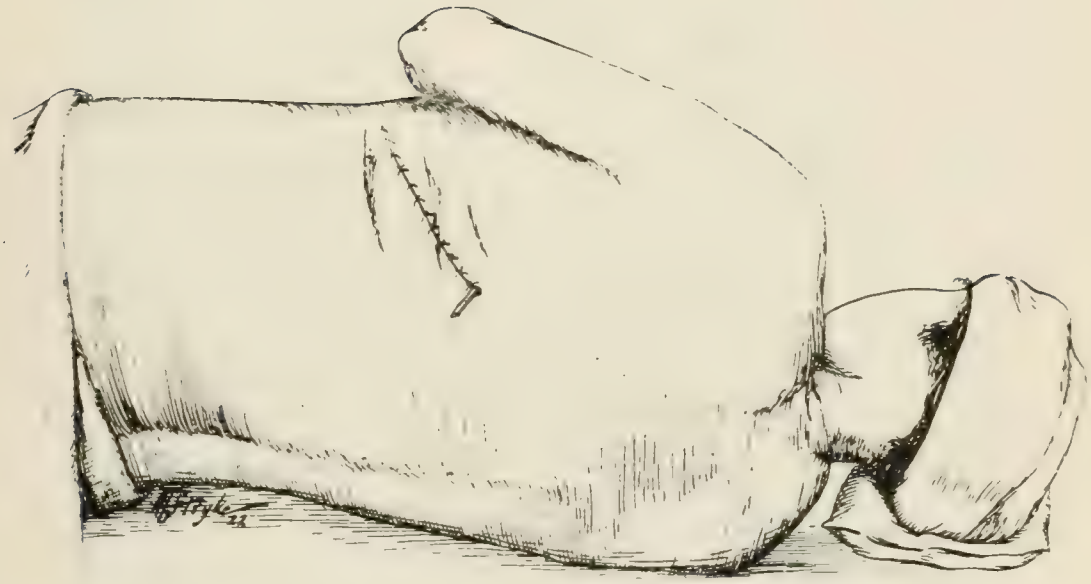
Semi-diagrammatic illustration of technic in chest surgery as followed in Case III. Examination of the tissues by the operator's hand.

FIG. 4.



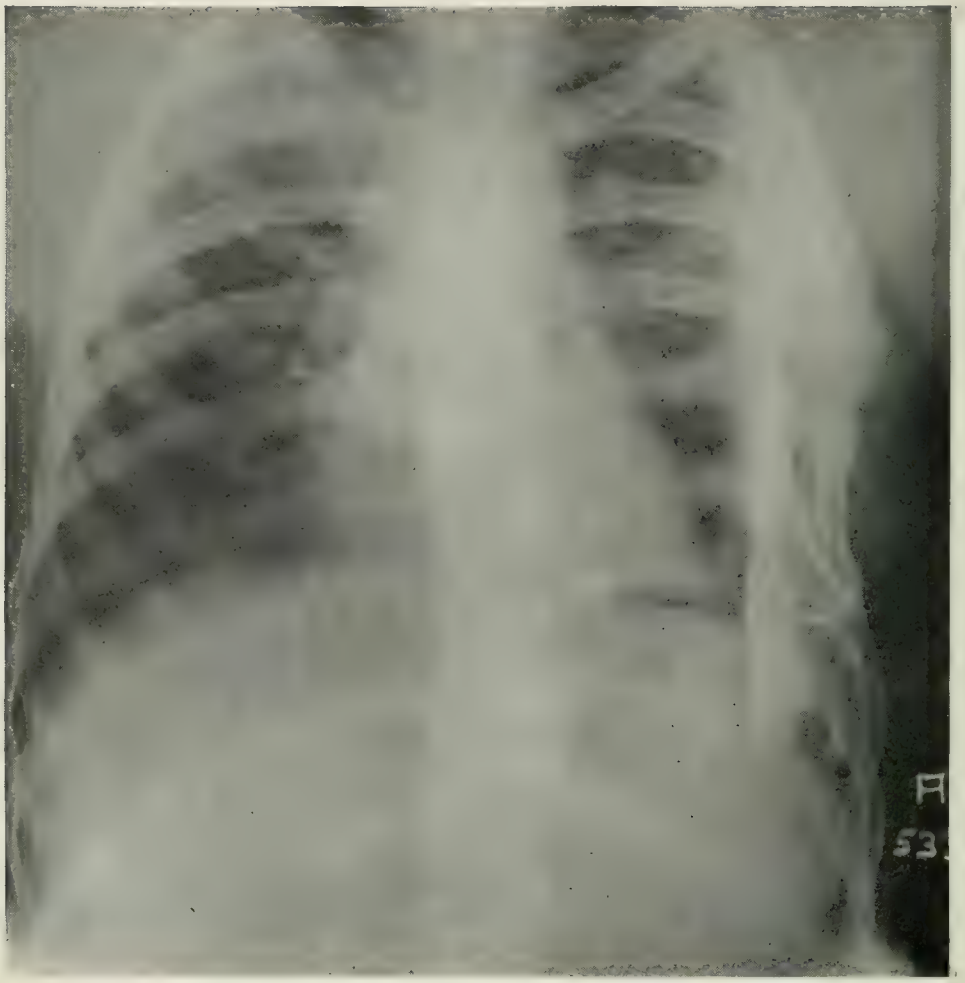
Semi-diagrammatic illustration of technic in chest surgery as followed in Case III. Lung grasped by forceps of the sponge-holding type. Note the closure of the freed bronchus by a purse-string suture of chromic catgut.

FIG. 5.



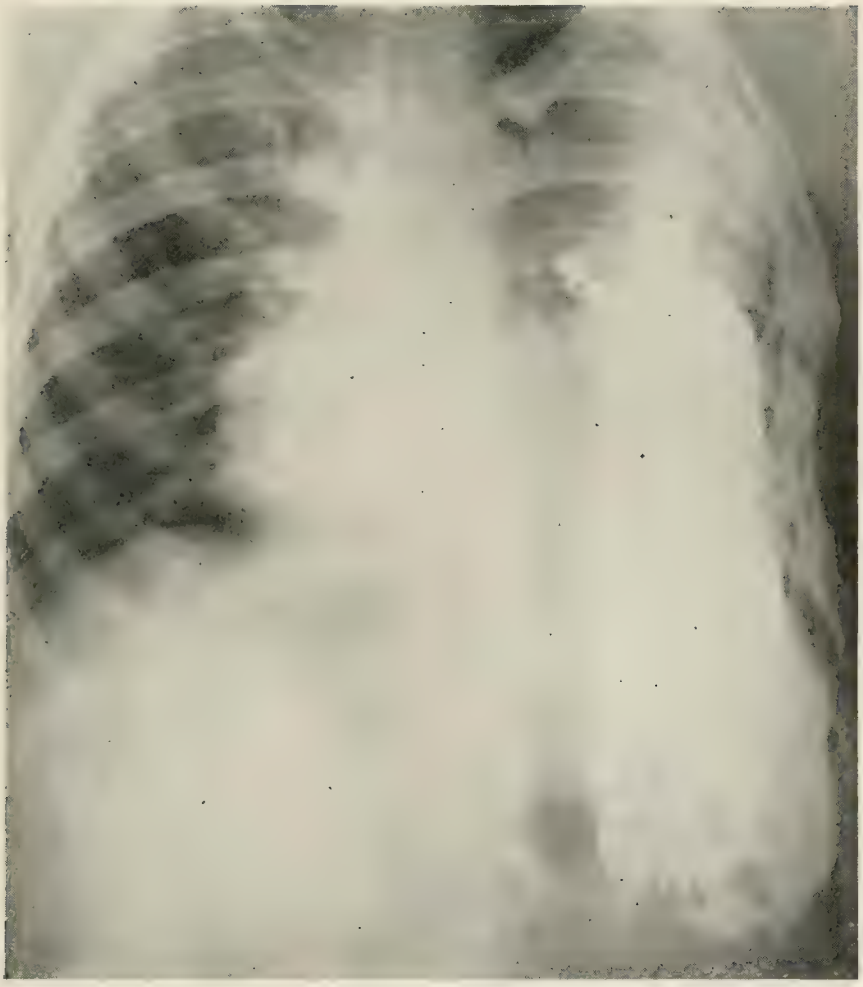
Semi-diagrammatic illustration of technic in chest surgery as followed in Case III. Incision closed, with drain in posterior angle of wound.

Fig. 6.



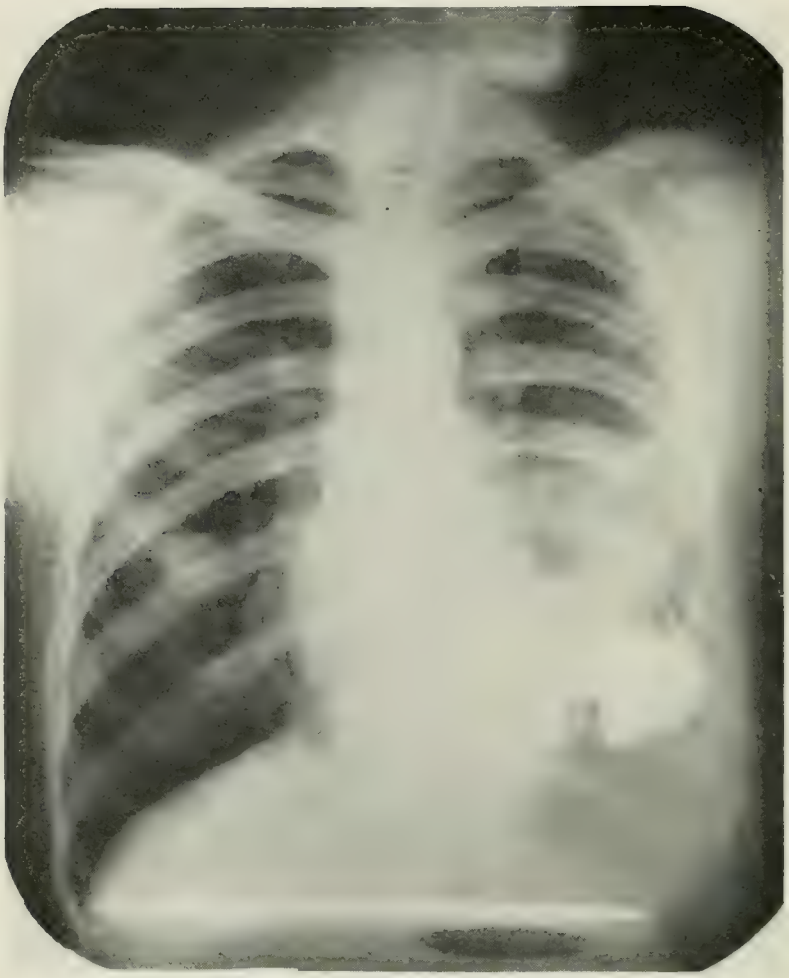
Case I.—A. B. Size of empyema cavity after first injection of bismuth paste.

Fig. 7.



Case I.—A. B. Empyema cavity greatly enlarged by the pressure of injected bismuth paste.

Fig. 8.



Case I.—A. B. Illustrating type of cavity suitable for treatment with bismuth paste.

bronchial fistulæ. (Two patients are now under the author's care, suffering from bronchial fistulæ, the result of improper drainage.)

(*c*) Neglected empyemas, resulting in lung abscesses. This is not an uncommon source of lung abscess. The pus may rupture into a bronchus either from too long delay in primary drainage or when sinuses are allowed to close before the empyema cavity has been sterilized and the lung expanded.

(*d*) Too prolonged drainage. Many empyemas of long standing will promptly heal if the cavity is sterilized with Dakin's solution or mercurochrome and the tube removed.

The treatment of empyema resolves itself into drainage and sterilization of the pleural cavity. The time to drain is determined by the character of the infection. Pneumococcus empyemas should be drained as soon as frank pus forms. Streptococcus empyemas should not be drained until the patient has developed an immunity to the generalized infection. Tubercular empyemas should never be drained.

The vast majority of empyemas can be cured by the closed method of Mozingo with sterilization by Dakin's solution.

Chronic empyemas are best healed by decortication after sterilization by the Carrel-Dakin technic.

Long-standing, difficult cases can be healed best by extensive rib resections with implantation of skin flaps, as advocated by Emil Beck (Figs. 4 and 5).

II. *Lung Abscess.*—Since tonsillectomy has become so common an increased number of lung abscesses are being reported post-operative. Operations on the throat in the sitting posture, especially under general anæsthesia when the throat reflexes are abolished, are more likely to be followed by this complication. A sudden rise in temperature after tonsillectomy should suggest lung abscess and lead to a careful examination checked up by X-ray pictures of the chest. Lung abscess will often break through into the pleural cavity and cause a secondary empyema. Neglected empyema, on the other hand, frequently breaks through into the lung, resulting in lung abscess. Both of these complications can be forstalled by frequent X-rays and early drainage. The surgeon should make sure that adhesions have formed between the visceral and parietal pleura before attempting

drainage. If no adhesions have formed after resecting a rib at the proper site, the space at the site of the proposed opening should be packed with gauze for 48 hours. A cautery or forceps can then be safely pushed through the pleural and lung tissue to the abscess cavity. Bronchial fistulæ following drainage of lung abscess are often difficult to close. The essential points in securing closure of such fistulæ are:

(1.) Lung expansion; (2) sterilization of the abscess cavity. (The writer has found one per cent. mercurochrome a valuable agent in sterilizing old empyema and abscess cavities. The actual cautery and strong caustics are also valuable.) Cases 3 and 4 illustrate both types of abscess referred to above.

III. *Advanced Pulmonary Tuberculosis.*—Increasing experience in thoracic surgery has revealed the fact that certain, otherwise hopeless, cases of pulmonary tuberculosis can be cured or greatly benefited by surgery. Cases suitable for surgical treatment are those with large, rigid-walled abscess cavities in the upper or middle lobes of one side with a comparatively sound lung on the opposite side. These cases should be carefully selected by men skilled in pulmonary examinations in conjunction with competent radiologists. The operation should be done under local anæsthesia and it consists of multiple extra pleural rib resections.

The purpose of the operation is to mechanically compress the lung by causing the chest wall to collapse and thus squeeze the pus out of the abscess cavity. It is a substitute for the minor surgical procedure of nitrogen inflation of the pleural cavity. The collapsing operation should not be resorted to until repeated attempts have been made to collapse the lung with nitrogen. Extensive firm adhesions precluding the use of nitrogen inflation furnish the indication in suitable cases. Abscesses located in the middle or lower lobes can be satisfactorily compressed by resecting from the tenth to the fifth ribs. Abscesses located in the upper lobe will require resection of all the ribs from the tenth to the first, inclusive, and it is sometimes necessary to resect the clavicle.

The pleura should never be opened. The complete operation would better be done in two stages. Cases 5 and 6 are illustrative of this type of operation.

Fig. 9.

Case I. —A. B. Granulating wound of chest two weeks after operation for implantation of flaps.

Fig. 10.

Case I —Wound healed, cavity entirely lined with epithelium.

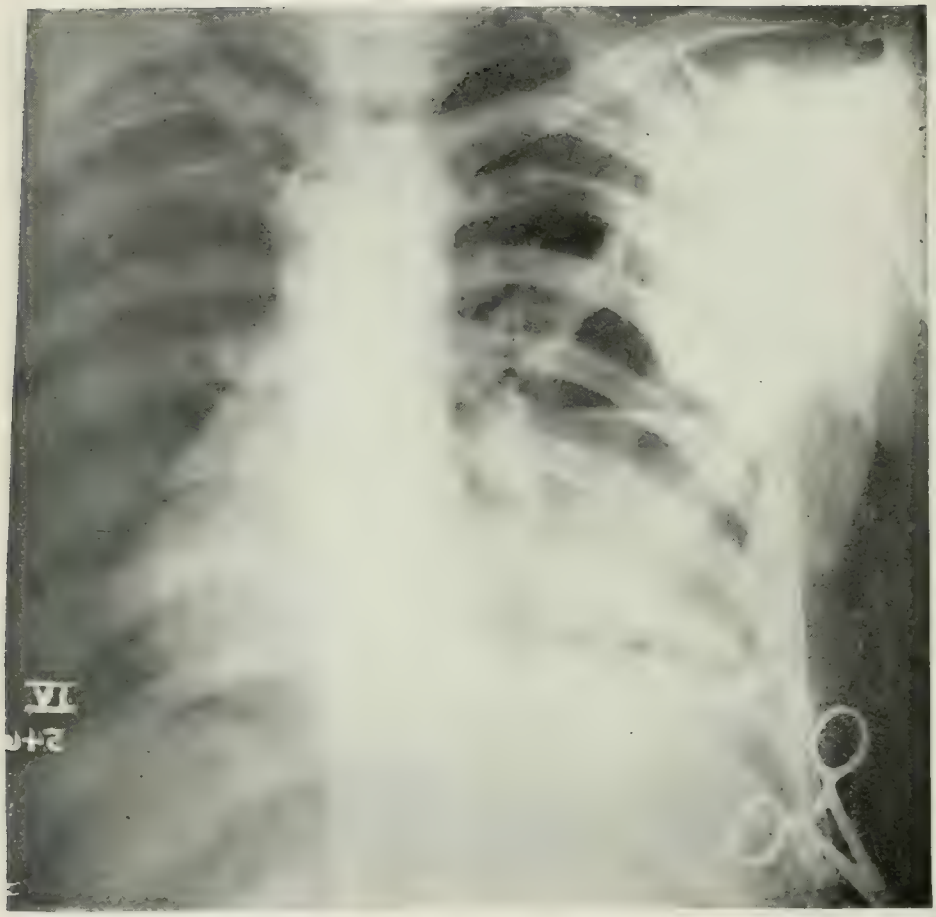
Fig. 11.

Case I.—Front view, showing final results with small amount of deformity.

Fig. 12.

Case II.—Frye. Shadow, indicated by arrow, represents an interlobar abscess.

Fig. 13.



Case II.—Frye. Interlobar abscess drained.

Fig. 14.

Case II.—Frye. Abscess at the level of second rib. Drainage tube is seen in interlobar abscess.

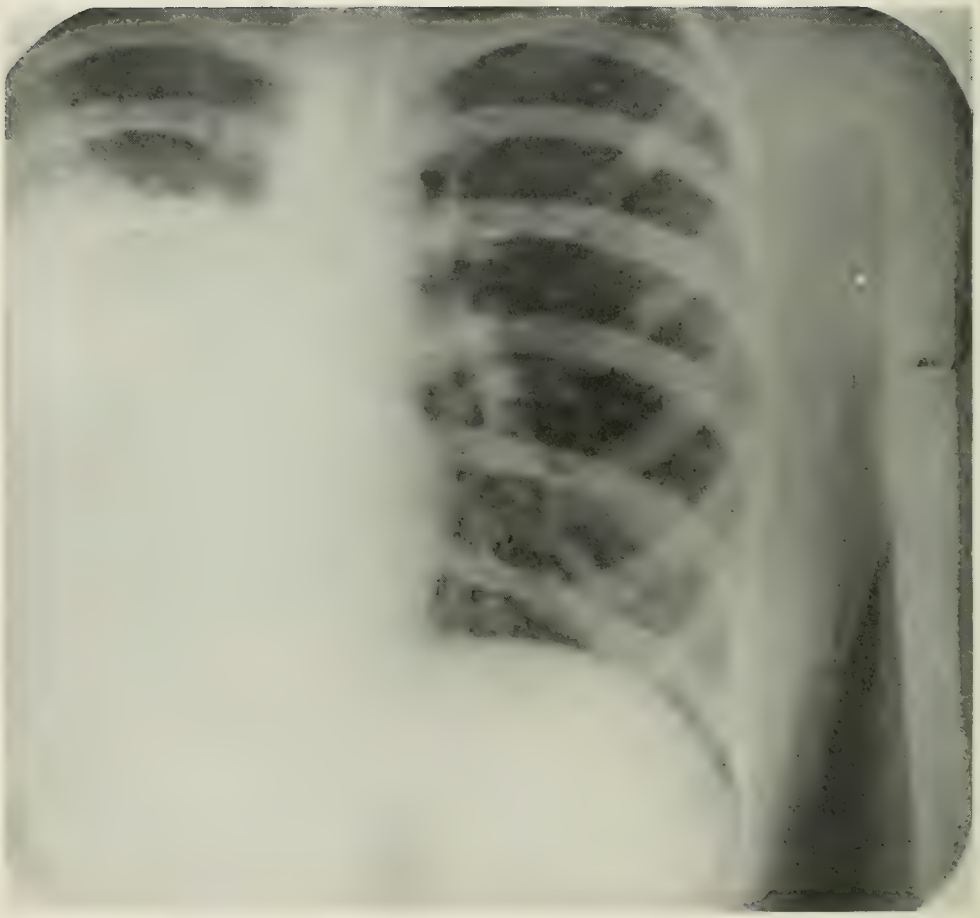
Fig. 15.

Case II.—Frye. Abscess at the level of the second rib near the mediastinum has been drained. Some pleural thickening remains.

Fig. 16.

Case III.—Mrs M. C. 7-9-21. Arrow indicates abscess in left lower lobe.

Fig. 17.



Case III.—Mrs. M. C. 10-18-21. Abscess has ruptured into pleural cavity and pus has partly filled the chest.

I am indebted to Dr. Carl H. Parker for the X-ray work on this series of cases and to other members of the group for valuable assistance in preparing this paper.

REPORT OF CASES

CASE I.—A. B., age 25. First seen in January, 1919. He had come to California for his health. In 1916 he had lobar pneumonia followed two weeks later by empyema. Rib resections with drainage tube did not result in a cure. The sinus continued to drain for three years. In February, 1919, Doctor Jonas, of Omaha, did an Estlander, resecting five ribs. Following this there was great improvement in general health, but sinus continued to discharge. An attempt was made to heal the sinus by injections of bismuth paste. Three injections were made at intervals of one week. There was improvement after the first injection and diminished discharge, but subsequent injections caused an increase in temperature and the cavity became progressively larger (see Figs. 6 and 7). It was decided that the case was not suitable for this treatment and it was discontinued. The sinus continued to discharge intermittently and condition was unimproved. (Fig. 8 illustrates a case suitable for bismuth paste).

March 3, 1920.—After rendering the cavity sterile by the Carrel-Dakin method, operation was undertaken to close the cavity. The ninth, tenth, and eleventh ribs were resected, all pockets obliterated and adhesions divided. Skin flaps were dissected up and sutured over the defect in the chest wall. A small drain was left in the wound. Following this operation there was great improvement in the patient's general condition. The discharge diminished and cavity became smaller, but the sinus persisted.

Finally, on July 15, 1921, the cavity was reopened, the lung decorticated and large pedunculated flaps of skin tacked to the bottom of the cavity with catgut stitches. The wound was left wide open and packed with iodoform gauze (see Fig. 9). The operation was a severe one and caused considerable shock, but patient rallied and rapidly regained his full strength. Granulations soon bridged over the area uncovered by skin flaps and after six months the entire cavity was lined with epithelium. The patient is now in excellent health, his empyema cavity is healed, and there is no noticeable deformity (see Figs. 10 and 11).

CASE II.—Frye, aged 38. Family history negative for tuberculosis.

January 28, 1920, developed right lobar pneumonia; crisis on eighth day. Temperature remained normal for two weeks, when he developed a pleurisy with effusion.

March 9, 1920, entered the Pasadena Hospital; very sick. Temperature, 100.2. X-ray picture showed the right pleural cavity filled with fluid; aspiration showed a seropurulent fluid. Drainage was established by the introduction of a No. 16 catheter through a trocar. Temperature dropped to 99° and remained about normal for one week.

March 23rd, temperature rose to 104°. X-ray picture (Figs. 12 and 13) showed an interlobar collection of pus at the level of the sixth rib. This was drained by resection of the seventh rib in the anterior axillary line. X-ray (Fig. 14) showed tube in abscess cavity and a new abscess forming higher up to inner side of apex of the lung and near the mediastinum. Temperature dropped

to 101° and remained around 101 until March 31st, when another radiograph was taken, showing a well-developed abscess near the mediastinum.

April 4th, eighth rib was resected and a portion of the seventh previously resected. Chest cavity was widely opened so that the hand could be passed up over the apex of the lung to the mediastinal abscess. Two ounces of fetid pus were evacuated and a large drainage tube introduced. After this operation patient immediately began to improve, temperature gradually returned to normal and has remained normal since. He is now entirely well (see Fig. 15).

Case III.—Mrs. M. C., age 30. Referred by Dr. C. C. Browning.

History of Case.—Six years ago patient had tuberculosis of the right lung, which completely healed. Six months ago she had influenza pneumonia, followed by an abscess in the lower lobe of the left. She has run an irregular temperature ever since, 101 to 104°, and has expectorated four to six ounces daily of a fetid, yellow pus. This pus showed only staphylococci and colon bacilli.

Examination.—When first seen, patient was cyanotic, emaciated and weak. Physical examination revealed signs of a large cavity in the lower lobe of the left lung. X-ray pictures showed consolidation of the entire left chest. Earlier pictures, however, show an abscess localized in the lower lobe.

Operation.—Resection of eighth rib in post-axillary line. A well-walled-off cavity was entered through lung tissue. Only slight drainage for two weeks, when there was very copious drainage with great relief. Periodic flooding with pus, followed by improvement.

January 29, 1922, second operation. Seventh and portion of eighth ribs resected. Large cavity entered in upper portion of lower lobe. It communicated by a small opening with old cavity at a lower level. Thorough drainage, followed by rapid improvement, great gain in weight; bronchial fistula persisted.

June 29, 1922, third operation. Eighth rib resected from posterior axillary line to the costo-cartilagenous junction. Skin opening and scar of former operation excised, ribs widely separated by rib spreader, dense adhesion of lung to parietal pleura freed up to the large opening in the bronchus.

Abscess cavity was explored and found to be about 3 x 2 cm. in dimensions, filled with granulating tissue. Cavity and sinus were swabbed with 2 per cent. gentian violet in 70 per cent. alcohol. The thoroughly freed bronchus was closed by a pucker string suture of chromic catgut (Fig. 4). The wound was closed in layers, leaving only a cigarette drain in the posterior angle of the wound (see Figs. 16 to 20).

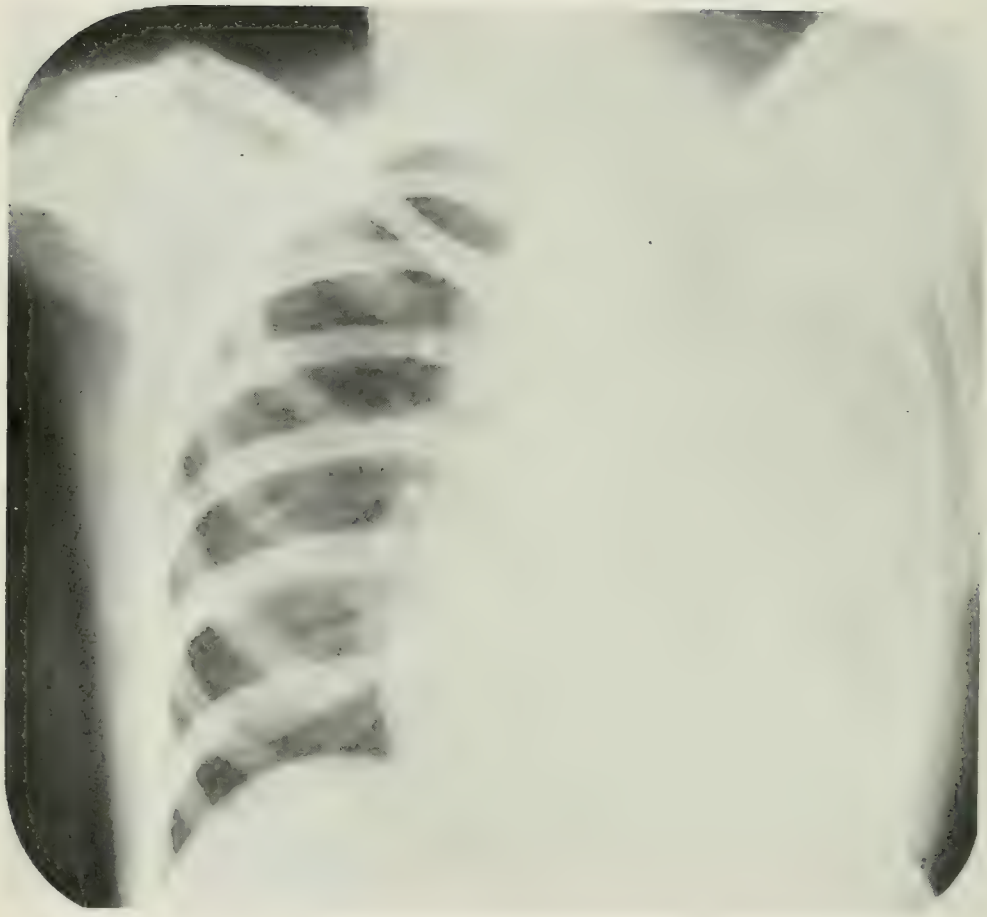
August 24, 1922, this patient had a rather stormy convalescence with high fever for three or four days. The discharge, at first bloody, soon changed to a thin seropurulent fluid. The sinus rapidly healed, the temperature returned to normal and the wound was entirely healed in four weeks. There is still about one ounce of odorless muco-pus expectorated daily. It is steadily decreasing.

Case IV.—Miss D. E. H., aged 23. Referred for abscess of the lung, secondary to empyema. At the age of 11 she had a simple pneumococcus pneumonia, followed by empyema. It was drained and remained healed for 1½ years, when pus again accumulated in the chest cavity. The cavity was again drained at the age of 16 and a piece of necrosed rib removed. The empyema cavity intermittently closed and opened about every six months until January, 1922, when she suddenly felt something give way in her chest and began to expectorate large amounts of fetid pus. She was expectorating 8 ounces of pus daily when first seen.

Fig. 18.

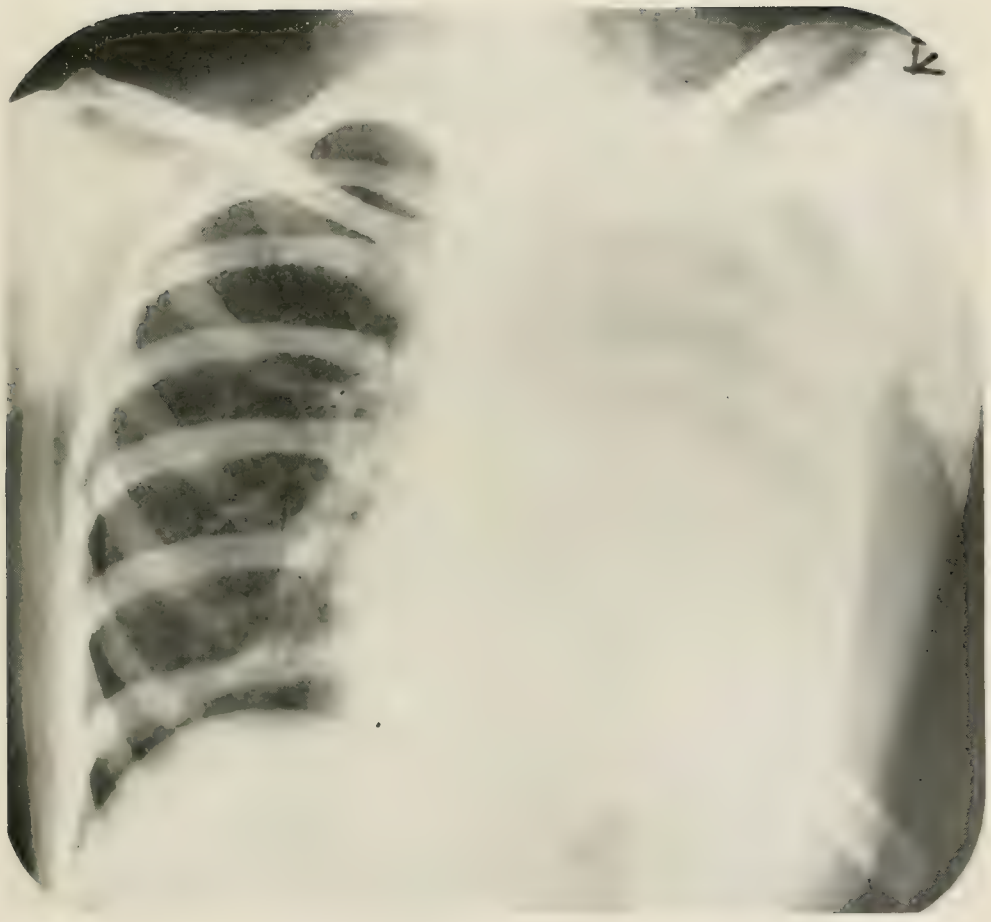
Case III.—Mrs. M. C. 12-8-21. Pleural cavity entirely filled with pus.

Fig. 19.



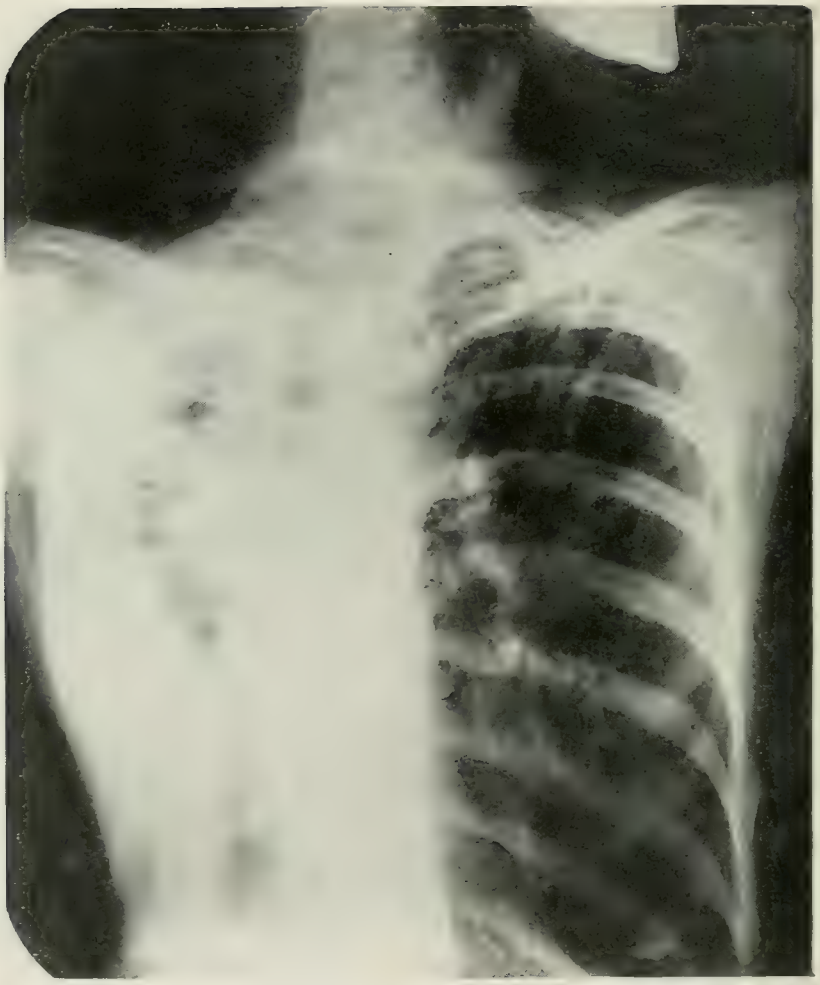
Case III.—Mrs. M. C. Abscess in lower lobe drained. Tube *in situ*. Chest somewhat cleared.

Fig. 20.



Case III.—Mrs. M. C. Abscess in upper lobe communicating with abscess in lower lobe; has been drained.

Fig. 21.



Case V.—Mrs. F. S. X-ray taken after resection of 5 ribs, showing collapse of chest wall on left.

Examination showed absence of respiratory murmur from the fourth rib to the base of the left lung. There was a small discharging sinus at the site of former operation in the nipple line. X-ray plates showed a uniform shadow over the entire left chest. This was clearly a case of lung abscess resulting from a neglected empyema.

Operation.—June 12, 1922. Eighth rib resected from anterior axillary line to site of fistulous opening. Fragment of rib formerly resected removed with scar tissue. Cavity exposed by rib spreader. Thick cicatricial membrane covering lung incised and removed. Pucker string of No. 2 chromic catgut placed about the opening in the bronchus. Following operation the cavity was thoroughly treated with Dakin's solution for ten days. A small drainage tube was then substituted for the Carrel tubes and one ounce of one per cent. mercurochrome introduced daily. Under this treatment the lung rapidly expanded, discharge has ceased, bronchial fistula closed and patient is rapidly gaining in weight and strength.

CASE V.—Mrs. F. S., age 35, American.

Family History.—Father, age sixty, living; in poor health. Mother, age fifty-five; in good health.

Past History.—Patient broke down in 1906, while a student at Stanford University, and developed a tubercular pneumonia from which she recovered after three years of care. In 1918 had a severe attack of influenza, with high fever. On the fourteenth day of the disease she had a severe pulmonary hemorrhage, followed by free expectoration of pus. Since that time has had periodic attacks of high fever with a feeling of tightness in her chest. This would be followed by the expectoration of large quantities of pus; she would then rapidly improve and temperature return to near normal. This condition continued up to July, 1920, when she was referred to me for operation.

At the time of operation the chest showed, on physical examination, all of the symptoms of cavity formation in the right upper lobe and an arrested tubercular process on the left. The diagnosis was bilateral tuberculosis of the lungs. Fibrosis of the left lung, large cavity in upper lobe of the right lung.

Operation.—Extra pleural thoracoplasty under local anæsthesia, aided by nitrous oxide. From the tenth to the sixth ribs, inclusive, were resected.

Results.—Wound healed by second intention. Improvement for first three months, with lower range of fever and lessened expectoration. Condition then became worse, and although much better than before operation, is still running an irregular temperature, with copious expectoration of pus periodically. The indication is for further compression (see Fig. 21).

CASE VI.—C. C., male, age 22. Had influenza pneumonia one year ago. Recovered, and six months later, while boxing, was struck quite a heavy blow on the chest. Immediately following this he spat blood. Pneumonia again developed, lasting four days. Patient never recovered from this second attack of pneumonia, but continued to have intermittent pulmonary hemorrhages up to the date of his operation. For the three days prior to the operation he had been bleeding very actively, losing as much as eight ounces at a time. The day before entering the hospital he lost a pint of blood.

Radiographic Diagnosis.—By Dr. C. H. Parker.

Pulmonary tuberculosis of the right lung, with a destructive process involving the whole right apex and pleural adhesions at the right base.

This case was desperate; all medical treatment had failed. Surgical intervention was a "*dernier*" resort. The day before the operation the patient was given 500 c.c. of citrated blood. The following morning an extra pleural thoracoplasty was done, resecting from the fifth to the tenth ribs, inclusive. Infiltration and para-vertebral anæsthesia was used, supplemented by a small amount of nitrous oxide.

Post-operative Course.—There has been no hemorrhage since day of operation, over five months ago, until the present time. There was great temporary improvement, with marked gain in weight. Two months after operation he developed œdema of the arytenoid cartilages, probably tubercular in origin. He recovered from this and was again gaining when he developed an ischio-rectal abscess. This was aspirated and found to contain staphylococci. It has refilled once and was opened under nitrous oxide anæsthesia. Fearing that it was tubercular in character, 12½ milligrams of radium was imbedded in the granulating mass through a rectal speculum. The radium was left in for four hours. There has been complete relief of pain with almost entire disappearance of the tumefaction in the rectum. The patient now is free from symptoms and rapidly gaining in strength and weight (see Figs. 22 and 23).

Fig. 22.

Case VI.—C. C. Abscess in upper lobe of right lung with diffusion. Tuberculosis throughout the lung.

Fig. 23.

Case VI.—C. C. Advanced case of tuberculosis. After multiple rib resection showing partial collapse of chest wall.

ALCOHOLIC INJECTIONS IN MALIGNANCY FOR RELIEF OF PAIN

By DR. GEO. M. DORRANCE and DR. J. WM. BRANSFIELD
Surgeons to St. Agnes Hospital, Philadelphia, Penna.

Influenced by the fact that our cases of neuralgia of the fifth nerve obtained immediate and in many cases permanent relief of all pain by the injection of 80 per cent. alcohol into the nerve trunks or the ganglion, we adopted this treatment for the relief of pain in malignancy about the face before or after operative procedures.

The fact that alcoholic injection causes anæsthesia of all the area supplied by the fifth nerve and paralysis of the muscles of mastication is no contraindication for any local treatment directed against the malignancy and is a decided factor in preserving the general health of the patient.

Preliminary injections of novocain into the nerves of the trigeminus or its ganglion solely for its anæsthetic purpose to permit operation has been advocated by many surgeons, but the post-operative use of alcohol in cases suffering from the pain caused by X-ray and radium treatments has not been generally used, as far as we know.

The most severe pain we have ever seen has occurred in cases following the use of radium; these cases do not respond to massive doses of opium, and it is in this type of case we feel alcoholic injections are imperative not only to relieve the pain but to permit further operative or radium treatments.

We cannot explain why these patients have such acute pain following the use of radium, particularly radium needles, when a barage treatment is employed.

The pain, as a rule, occurs in about a week to ten days after treatment and becomes unbearable in about two to three weeks.

On operating on cases following the use of radium, we have observed that a dense fibrosis of the tissue occurs with obliteration of the vessels, and we have thought that this same fibrosis may occur in the nerve trunks; at all events, it is certain that the nerve is severely crushed in the contracting sclerotic tissue.

Frequently, it is simply necessary to inject the nerve supplying

the painful area to obtain relief—at times we must inject the entire division as the second or third division of the fifth nerve, while rarely it is necessary to inject the ganglion itself.

In the injection of the divisions of the ganglion and of the fifth nerve, we still use the method advocated by Hartel, with some slight modifications.

Our technic is as follows: The instruments required are few; a ruler and a trocar needle, preferably of platinum, which is graded in millimetres. On this needle there is a small set-screw which

Fig. 1.

Anterior view with line bisecting the pupil.

before starting the injection may be set for any depth; an ordinary hypodermic set; a solution of one per cent. sterile novocain; a solution of alcohol, C.P. 80 per cent. strength.

Technic for the third division and for the ganglion is the same, excepting that the needle is introduced farther for the ganglion injection. A large portion of the ability to correctly inject the novocain is due to the following out of very definite rules. The remainder comes from experience gained by practice on the cadaver.

It is first necessary to select a point 2½ cm. external to the angle of the mouth on the same level. A line is drawn with a blue pencil upward from this point so as to bisect the pupil of the eye (Fig. 1).

The second rule is to have the ruler placed at the point external to the angle of the mouth, the other point on the articular eminence of the zygoma, drawing the second line also with a blue pencil. The needle is introduced. In looking at the needle from the antero-posterior direction, it must follow the direction of the line which bisects the pupil of the eye, and on looking at it laterally the needle must be in the direction of the line running to the articular eminence (Fig. 2). If you will note on the skull, you will find that the needle will be found to enter the foramen ovale (Fig. 3). The actual technic

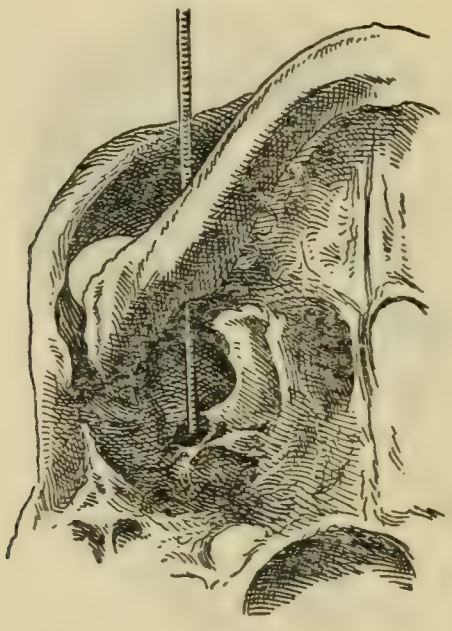
FIG. 2.

Line to articular eminence of zygoma and direction to ganglion.

then consists in the patient resting on the table either flat or in a slightly elevated position looking straight ahead. The guard of the needle is set at 5½ cm. from the point; the left index finger is placed in the vestibule of the patient's mouth; the needle is introduced into the cheek through the point 2½ cm. from the angle of the mouth and passed inward in the direction as mentioned, in which it corresponds to the line drawn from this point to the pupil of the eye and in the direction of a line drawn from the point 2½ cm. from the angle of the mouth to the articular eminence. The needle is gradually advanced until the patient complains of pain in the ear and in the

third division of the fifth nerve, care being exercised not to puncture the mucous membrane of the mouth. The needle now corresponds to the direction of the two lines noted; inject a half c.c. of the two per cent. solution of novocain. In approximately one minute, loss of sensation will be noted over the distribution of the third division. If anæsthesia does not occur after three minutes, you have not struck the nerve. If anæsthesia has resulted, we then inject 1 to 2 c.c. of alcohol. We then wait for five minutes to see if the anæsthesia becomes complete.

Fig. 3.



Needle in foramen ovale looked at from below.

If you desire the ganglion injection, the needle is introduced from ½ to 1 cm. further, and a distinct feeling of the needle passing over the bony margin will be noted and peculiar resistance given to the needle on entering into the ganglion. Here, again, we first inject the 1 c.c. of one per cent. solution of novocain and note the anæsthesia. If anæsthesia of one or more branches is noted, we inject the alcohol very slowly. It will be found that the injection requires some slight pressure on the plunger of the syringe. We then wait five minutes to see if the anæsthesia is as desired. If only the lower two branches become anæsthetized, it is necessary to introduce the needle slightly farther and inject a little more alcohol. If, at any time, the alcohol enters without pressure on the syringe, one should stop immediately,

Fig. 4.

Sketch showing needle in ganglion.

as you have entered the sub-ganglion space or pierced the dura. Quite frequently, one will miss the foramen, and then one must depend upon the touch of the tip of the needle. If the area is rough, you know that you are posterior. If it is smooth, you are internal or anterior. A study on the cadaver very quickly gives you the anatomy as felt at the needle tip. If we fail at first, we frequently withdraw the needle and make an entirely new start (Fig. 4).

The essential part of the entire procedure is to draw two lines, as indicated in Figs. 1 and 2, on the face, and not trust to the eye. We feel that more can be gained by studying the photographs than by minute description.

When we wish to inject the second division of the fifth nerve, the method advocated by Patrick gives very satisfactory results.

In all injections we give a preliminary hypodermic of morphine, gr. ¼, and infiltrate two per cent. solution of novocain at point of puncture. If the patient is very nervous, nitrous oxide is administered, using the nasal inhaler.

THE USE OF THE EPIDERMIC GRAFT IN PLASTIC EYE SURGERY

By JOHN M. WHEELER, M.D.
New York City

We owe a debt of gratitude to Jacques Reverdin, of Geneva, interne in the hospital Necker in Paris. He was familiar with the appearance of islands of epithelium which presented themselves on granulating surfaces of ulcers, as a result of proliferation of the epithelial lining of the deep-lying glands of the skin, and the possibility of hastening the formation of an epithelial covering by transplanting islands of epidermis from another part of the body occurred to him. A boy appeared with a raw surface on one of his thumbs and Reverdin took two particles of epidermis (about 1 mm. in diameter) from the boy's arm with a lancet, and planted them on the granulating surface of the thumb. The grafts lived, entered into union with the underlying tissue and proliferated, thus materially aiding the epidermization of the raw surfaces. This successful experiment in epidermic grafting was reported and published in 1869,[1] but it excited very little interest amongst French surgeons.

In 1872, M. Ollier, of Lyons[2], presented a communication on cutaneous grafts, and advocated the use of detached flaps 4 to 8 cm. square, comprising not only the epidermis, but also the true skin, and M. Ollier thought the connective tissue of the derme played the principal rôle in skin grafting.

Thiersch, of Leipzig, in 1874 advocated the method already described by Ollier, and in 1886[3], added a few points in technic. For covering raw surfaces, he suggested the use of grafts including epidermis and part of the stroma of the true skin of the arm. He said that the pieces of skin might be 2 cm. wide and 10 cm. long.

To those who are interested in studying the history, operative techinc, indications, results and complications in connection with the Ollier-Thiersch method of skin grafting let me recommend Gabriel Beaure D'Augeres' thesis for the degree of doctor of medicine published in 1904[4].

It is best not to use the name of Thiersch in connection with the

epidermic graft, as the graft which he employed was dermo-epidermic. The ideal razor graft includes the superficial and deep layers of epidermic (epithelium), with possibly parts of the papillæ of the corium which project into the epidermal layer. One should be familiar with the histology of the layers of epidermis and true skin. In cutting a graft, entrance into the papillary layer is indicated by bleeding points, as vascular loops extended into the papillæ. Most of the pigment carried by the skin is in the deep layers of the epidermis and very little in the corium. So a graft which extends only as deep as the papillæ of the corium includes most of the skin pigment. As a rule it is best to use skin of the patient who is to receive the graft, for if the grafts are taken from another person there is less likelihood of a "take." Moreover, there is the danger of transmission of disease, also the danger of lawsuits from the grantor. This danger is genuine, as has been pointed out by Cotton and Ehrenfried.[7]

EXENTERATION OF THE ORBIT

After removing the contents of an orbit for intraacular growth the surgeon may allow granulation tissue to grow and the skin to close over it, but the process is slow. So some surgeons chose to hasten the epidermization by grafting. Usually grafting is done some time subsequent to exenteration of the orbital contents, after granulations have formed on the orbital walls, but it is not necessary for the surgeon to wait for granulation tissue formation. He can graft epidermis immediately after removing the orbital contents, with assurance of success. Epidermis will "take" on bone, as well as on muscle, tendon, fascia and periosteum. Plastic operations have been planned and performed to prepare a socket for an artificial eye after removal of the orbital contents, but a restoration cannot be made with good cosmetic effect. If the patient does not care to wear a patch, a prothesis can be made which will cover the orbital cavity, and reasonably well imitate eyelids, cilia and eye, and this can be attached to a spectacle frame.

To line the orbital cavity, either large epidermic grafts or strips of epidermis can be used. The grafts are placed in the orbital cavity, raw surface toward the orbital wall, with sufficient overlapping. Then a covering of rubber tissue with the thinnest smear of vaseline is placed over the grafts, and the cavity is tightly packed with dry gauze and the pressure dressing is applied. This is left without change

for about 1 week, when the dressing and protective tissue are removed. The grafted tissue should be anointed daily, but no dressing is necessary after the first week.

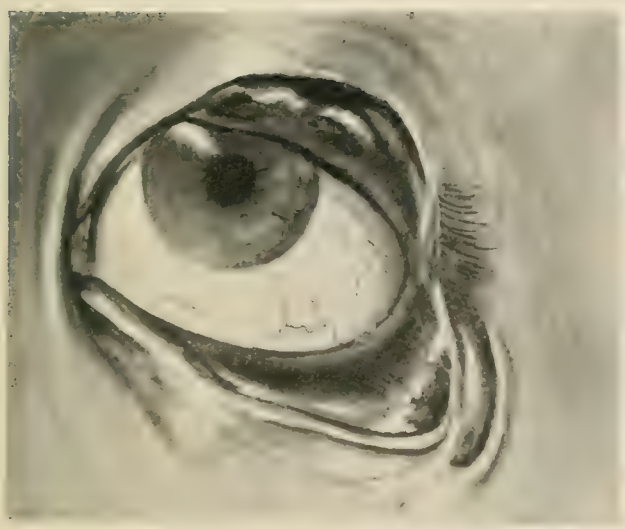
CICATRICIAL ECTROPION

J. T. Esser, of Holland, in 1917,[5] published a method of handling epidermic grafts which has received several modifications. By this method grafts are wrapped about a mould of dental impression compound, raw surface outward; then mould and grafts are buried in contact with the prepared raw-surfaced cavity wall by sewing the mould edges together over them, and later releasing the mould. The important point in this method is to get firm contact of raw surfaces.

Gillies[6] in England has used and advocated the Esser method and has referred to his adaptation of it for ectropion as "epithelial outlay." He describes the method of operating for ectropion as follows: "For ectropion of the upper lid, a curved incision is made just above the lid margin. This is deepened slightly, but not down to the tarsal plate, and care is taken as far as possible to avoid interference with the levator palpebræ superioris muscle. To a certain extent, the flap of skin lying above the incision between the incision and the eyebrow is undercut. This undercutting is continued until the lid margin descends to a lower level than normal. A mould is then taken of this cavity, covered with skin graft and the skin united again at the original incision. When the skin is thus sewn up again over the mould, the ectropion is more pronounced for the time being until the mould is removed. This incision is not tightly closed, so that there are one or two gaps in it which allow the new epithelium to grow around the margin of the incision. After the mould is removed there are certain disabilities that become apparent. There is no doubt as to the cure of the ectropion, but if a nice edge has not been produced, there is the appearance of an epithelialized ulcer, which, however, in the course of time, softens out remarkably with massage and the natural movement of the lids."

This method is far from ideal, not only because the results are not smooth, but particularly for three other reasons. First, the ectropion which endangers the cornea is rendered "more pronounced for the time being until the mould is removed," with increase of danger to the cornea. Second, creation of the extremely important inter-

FIG. 1.

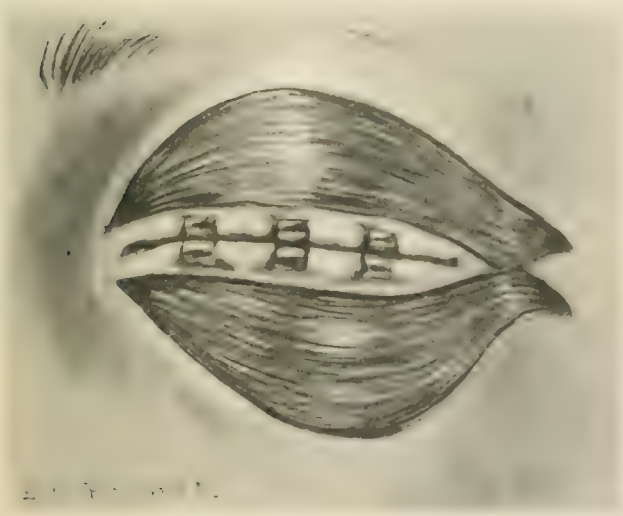


Severe ectropion, with cicatricial epicanthal folds.

FIG. 2.

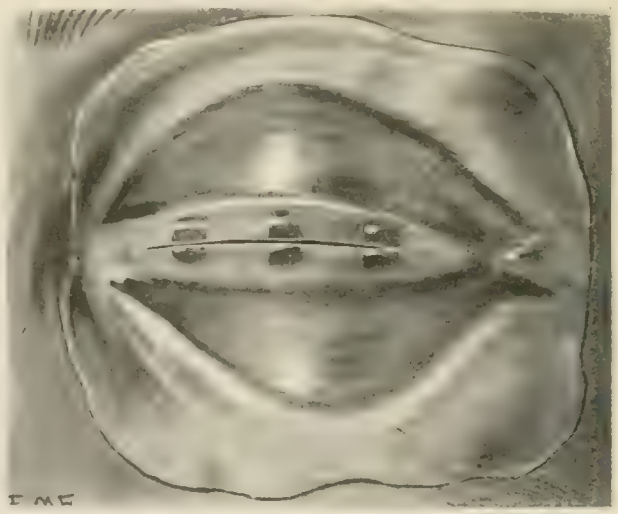
Dissection preparatory to skin grafting, the denuded areas of the upper and lower lids communicating at the temporal side of the palpebral fissure.

FIG. 3.



Three raw surfaces carrying mattress sutures and passing through small plates of rubber overlying the skin of both upper and lower lids near their margins.

FIG. 4.



Large piece of epidermis placed over lids, overlapping the denuded margins all around.

marginal adhesions is not possible in the process. Third, this method endangers the life of the lid margin, especially if there is considerable scar tissue along the edge of the lid.

For ordinary cicatricial ectropion let me advocate without reservation the use of true skin of the upper lid according to the method described by me before the eye section of the American Medical Association in 1921.[8] Many trials of this method were made before it was recommended. The results are surprisingly beautiful, and the technic is not difficult.

SEVERE ECTROPION

It is only for extreme ectropion from burns that I should use the epidermic graft. The severe type of ectropion usually involves all four eyelids, and is associated with large areas of facial burn, and possibly partial or complete loss of cilia and brows. The outer canthus may be pulled well down out of position and there may be cicatricial epicanthal folds. Fig. 1 represents this type of ectropion. In such a case it may not be feasible to implant true skin grafts and it is convenient to resort to epidermis. Fortunately, in these bad burn cases, epidermis matches the scarred tissue of the face about as well as true skin from a distant part, and it is possible with epidermis to cover as large areas as necessary.

Operation.—Usually general anæsthesia is called for in the severe cases. Figs. 2, 3, and 4 outline the procedure. After the preparatory dissection of the eyelids, there is a large exposure for the reception of the epidermic graft. Both upper and lower eyelids are repaired at the same sitting. The primary incisions should be parallel to the distorted lid margins. Cicatricial tissue should be so thoroughly and painstaking removed that there will be no tendency of the lid to evert, and scarcely more than normal resistance to traction at the lid margin. In making the preparatory dissection, the tissues should not be handled roughly. I sometimes go through the entire procedure without the use of forceps and so save injury to the tissue cells. Artery clamps should not be used unnecessarily and no ligatures should be used on bleeding vessels. Pressure usually suffices to control hemorrhage. If bleeding occurs in one field the surgeon can go to another and work until bleeding has stopped under pressure.

Let me suggest an important precaution in regard to the preparatory dissection of the lids. Usually in cases of bad deformity the dissection has to be carried well out beyond the external canthus. It is permissible for the denuded areas of the upper and lower lids to communicate at the temporal side of the palpebral fissure (see Fig. 2), but it is a mistake for the surgeon to establish a communication at the nasal side, as a fold will form during the healing process and make a cicatricial epicanthus, or accentuate the epicanthal fold if it already exists. This gives a cosmetic blemish for which we have no entirely satisfactory operation.

Either two or three firm adhesions between the upper and lower lids are made by dissecting off epithelium at corresponding positions on the upper and lower lid margins, and carrying mattress sutures through the little raw surfaces. They are passed through small plates of rubber (cut from sterile rubber tubing) overlying the skin of both upper and lower lids near their margins (Fig. 3). These sutures are tied snugly to insure firm apposition of the little raw surfaces. Union of these raw surfaces causes the formation of adhesions which hold the upper and lower lids together. Later, these adhesions stretch somewhat and are covered with a growth of epithelium. This stretching allows of very slight separation of the lids, so that the patient can see through the palpebral fissure, a thing to be encouraged, as elevation of the upper lid stretches the lower. With this in view, it is well to avoid making an adhesion directly in front of the pupil.

The Graft.—After passing the sutures to secure apposition of the raw areas of the margins, a single large piece of epidermis is placed over the lids, overlapping the margins of the denuded areas all around (Fig. 4). For this purpose a graft with an area of 9 to 12 square inches may be needed.

For taking the graft I am now using the Stille (Norwegian) graft knife, and an interested barber gives it an exquisitely sharp edge, without which it is impossible to get a large graft free from perforations and free from true skin. This knife has a long blade, and is like a large table knife. The lateral aspect of the thigh is usually the most convenient place from which to take the graft. No elaborate preparation is necessary. The part from which the epidermis is to be taken, is shaved and cleansed with alcohol and ether. Then with a long-bladed knife or razor with a keen edge, a large

piece of epidermis is taken. As Parker[9] has suggested, the skin and knife may be smeared with a thin coating of sterile vaseline to reduce the tendency of the skin to move with the knife. An assistant with a towel or gauze over the skin to prevent slipping, by using the edge of his hand, holds the thigh skin taut and flattens out the surface. The operator with one hand controls the skin surface, and with the other carefully shaves off the single large graft of epidermis (2½ to 3 inches by 3 to 3½ inches), taking care not to perforate and not to go too deep. With the hand, the skin surface can be so controlled that it can be depressed or elevated at different points as the need may be.

I know of no mechanical device that can take the place of intelligent and trained hands during the process of getting a large, truly epidermic graft.

The bed for the graft has been prepared, and it is immediately placed in position without being put into a solution of any kind and without manipulation. A laboratory teasing needle is of help in adjusting the graft. Forceps may injure the epithelial cells. No sutures are used but the pressure of a secure dressing and bandage are relied on to hold the graft firmly in place. After placing the skin in position a slit should be made in it just in front of the palpebral fissure to provide for drainage of conjunctival secretion (Fig. 4). It is well to make a slit also in the rubber tissue which is placed over the graft.

Dressing.—The graft should be covered with rubber tissue, having the slightest smear of sterile petrolatum. I prefer to put the tissue on in two layers with the grains running at right angles, to guard against the possibility of perforations, through separation of the tissue fibres. The rubber tissue will prevent the skin graft from getting dry. If a covering other than rubber tissue is chosen, it should have a smooth surface, be pliable and without perforations. Over the tissue, gauze fluff is packed and secured firmly by adhesive plaster, and then by a pressure bandage, which in turn should be secured by adhesive plaster. It may be well to put a separate dressing over the other eye, to be left for two or three days, and then to be cut down without disturbing the main dressing and bandage. This should be left for five days at the end of which time it is removed with the utmost care, and the graft painstakingly cleansed with damp

(not wet) boric acid sponges, and all sutures taken out. At the first dressing the grafted skin will appear slightly pink, not gray. The portions of the graft which extend beyond the denuded areas will slough. At the first dressing the grafted epidermis should be adherent to the raw surface underneath, held by fibrin. If any part of the grafted epidermis on the raw surface is loose, such part will die. Rubber tissue, gauze dressing and bandage, changed every two days, are continued for another week; then dressing is no longer necessary, and the graft is kept smeared with a little sterile petrolatum.

Thiersch used a sterile dressing moistened with salt solution and he poured on salt solution every 4 hours. It was formerly taken for granted that an impervious covering could not be used for fear secretion would not be taken care of, but such is not the case, for firm pressure will force secretion beyond the limits of the impervious protective covering into the gauze dressing.

About three weeks after operation, it is well to start massage with petrolatum. This is kept up daily for several weeks. The adhesions should be left until all tendency to malposition of the lids has passed. They are cut with the scissors and no deformity results from them.

Care of the denuded area on the thigh is very simple. Usually the graft has to be trimmed a little and any trimmings can be used to advantage by sticking them back on the denuded area so as to make islands from which epithelium will grow, and thus the time of the epithelization process is shortened. Either rubber tissue or vaseline gauze makes a suitable covering for the raw surface. Dry gauze is secured over it by adhesive strips and left for about two weeks, when the dressing can be taken off and left off.

If the brows have not been destroyed it may be worth while to graft from them for cilia line, before the interpalpebral adhesions are severed. Otherwise artificial lashes may be resorted to. If the brows have been destroyed grafts from the scalp can be placed in the brow positions.

An important question is apt to confront us in connection with the severe burn cases. It is whether to operate early, before the fascial burns are healed, or to wait until cicatrical contraction has progressed. To my mind the answer is clear. I should operate as soon as the physical condition of the patient will allow, even if it means

operating again later on. This judgment is based on the importance of protection for the cornea by the lids, which will be held by the adhesions between their margins.

SYMBLEPHARON

May[10] and others have reported satisfactory results by using skin grafts for the restoration of the cul-de-sac with the eyeball in position. The graft is held in place by a porcelain shell or other form. Personally, I have not had a result that pleased either the patient or me. After operation the conspicuous graft is unsightly, the lids are thickened, the motility of the eye is not completely restored, and in most cases the restoration of the cul-de-sac is not permanent. Moreover, ulceration of the cornea may result from the operation.

Restoration of Obliterated Socket.—Many suggestions have been made for making new sockets after obliteration, and many disappointments have resulted from various sorts of procedures. Gillies[6] and others have recently recommended adaptations of the Esser method and the term "epithelial inlay" has been used in referring to the method. I am firmly convinced that the Esser method is not the best for socket restoration, as far as results are concerned. And if the form and graft are buried through a skin incision near the edge of the eyelid, when the form is released by an incision made through the palpebral fissure, there is genuine danger of loss of the lid margin through interference with blood supply. Danger of sloughing of the lid margin applies especially if there is scar tissue anywhere along the margin.

The method which I have adopted and wish to advocate was described in detail in the *American Journal of Ophthalmology,* July, 1921.

If the lid margins are adherent, they are separated by an incision. The dissection is then carried out in such a way as to separate the lids from the orbital contents. The following points should be borne in mind:

1. *The dissection must be kept superficial* so that in front of the dissecting knife or scissors there is only lid tissue, *i.e.,* only skin, orbicularis, the thin fascia of the lid, and the tarsus. It is not necessary to save the tarso-orbital fascia with the lid. Carrying the

dissection back into the orbital tissue is probably one of the most common causes of failure.

2. Not only the superficial plane of the dissection but *the extent and limitation of the dissection* are of importance. Temporally and below, the dissection should be carried well to the orbital margin or even 1 mm. or 2 mm. beyond it, as the graft must adhere to the periosteum of the anterior aspect of the orbital margin. On the nasal side the dissection should be extended to the anterior crest of the lachrymal groove and to the orbital margin above it. In dissecting at the inner canthus the caruncle should be saved if it has not been destroyed. The graft will adhere to the posterior surface of the caruncle and give it a permanent lining. In the division of the tissues above, the dissection should be carried behind the orbital rim but not necessarily to the roof of the orbit. In some cases the levator palpebræ superioris can be saved.

3. In preparing the bed for the graft *all cicatricial tissue and granulation tissue should be removed.* Excision of granulation tissue is especially important as the contraction of such tissue may result in contraction of the socket. Reduction in size of the newly made socket is due to contraction of the underlying tissue rather than to contraction of the skin itself.

4. A common fault which manifests itself after restoration of the socket is that of too great *thickness of the lid margin.* This deformity can be obviated by cutting away tarsus. If the skin graft must extend completely to the margin of the eyelid, the tarsus may be split and thinned. If the graft is to extend nearly to the margin, sufficient tarsal plate may be cut away so that the graft will set in as an inlay. In any case, enough tarsus should be left to support the cilia, but not necessarily any more. A form should then be moulded to fit the cavity. Dental impression compound is ideal for this purpose. Ordinarily for full restoration of the socket, the dimensions are approximately as follows: length, 40 mm. to 45 mm.; width, 30 mm., thickness 4 or 5 mm.

The ideal graft for socket restoration is one without perforations, which is made up of epidermis only, free from layers of true skin, and large enough to be wrapped around the form of impression compound with generous overlapping. This means a graft 3½ to 4 inches long and about 3 inches wide.

The graft of epidermis is immediately wrapped about the form of impression compound, raw surface outward, and overlapped on the surface which is to be anterior. The form, completely covered with living epidermis, is next forced into the socket cavity. It is not necessary to remove small blood clots before placing it as they will not prevent a take. This overlapping portion of the graft is placed forward so that if the edges are disturbed by manipulation they can be carefully replaced through the palpebral fissure so that every part of the form will be covered.

No sutures are used. A pressure bandage is applied, and over this adhesive strips. Very firm pressure is of importance to secure accurate contact at all points and to keep the cavity absolutely obliterated. This first dressing is left in place for a week. The form is left in place and is not touched for about three weeks. It is then removed with a squint hook and left out permanently. The artificial eye may be introduced at any time. A mistaken idea is that the socket will be lost if an artificial eye or some form of dilator is not promptly introduced. I like to wait a week or more before putting in the prothesis, and it is permissible to wait any length of time. The cavity should be completely carpeted with skin. If there is a little break anywhere, a granulation may appear and have to be snipped off.

If the surgeon has been successful in carrying out the technic the result will be a permanent socket, extending well beyond the canthi and of sufficient dimensions all around. The lids will be normally thin and pliable and the thin-walled socket will not prohibit motility of the stump and artificial eye although the movements of the eye will be somewhat less than those following ordinary enucleation.

An interesting development is that usually lachrymal secretion will find its way into the new socket and maintain a comfortable moisture. As far as I know, trouble never results from activity of the lachrymal gland.

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